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Baghouse Efficiency on a Multiple Hearth Incinerator Burning Sewage Sludge

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BAGHOUSE EFFICIENCY ON A MULTIPLE HEARTH INCINERATOR BURNING SEWAGE SLUDGE

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Contract No. 68-03-3148

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16. ABSTRACT

A pilot-scale fabric filter (baghouse) was evaluated for its removal performance for 23 metals and for sulfur as well as for total particles when fitted to a multiple hearth incinerator burning sewage sludge. The small scale baghouse was installed to take a slipstream of about three percent of the total incinerator emissions. Particle size fractions were collected from the gas streams entering and leaving the baghouse. Each particle size fraction was analyzed for the 24 elemental species and baghouse performance was evaluated for overall removal efficiency, size fraction removal efficiency, and for selective removal of specific metals. Total concentrations of each element in the controlled emission stream was determined as well as the proportionate concentrations of species in the solid and volatile states. Concentrations of each metal in the emission stream was compared with the concentration in a sludge residue. To obtain comparisons of baghouse performance with a more typical emission control device, the performance of the incinerator's full scale wet scrubber was also evaluated.

The efficiency of the baghouse for collection of total particles was 99 percent compared to the 94 percent for the wet scrubber system. Its collection efficiency was superior for cadmium but the wet scrubber was much more efficient for collection of sulfur.

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing, and managing of research, development, and demonstration programs to provide an authoritative, defensible engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

Sewage sludge contains small concentrations of toxic metals whose losses must be controlled when sludge is incinerated. This investigation reports the improvement in removal efficiency that can be expected when a baghouse is used to control emissions instead of the more conventional wet scrubbing technology.

E. Timothy Oppelt, Acting Director
Risk Reduction Engineering Laboratory

ABSTRACT

A pilot scale fabric filter (baghouse) was evaluated for its removal performance for 23 metals, sulfur, and total particulates when fitted to a multiple hearth incinerator burning sewage sludge. The small scale baghouse was installed to take a slipstream of about three percent of the total incinerator emissions. Particle size fractions were collected from the gas streams entering and leaving the baghouse. Each particle size fraction was analyzed for the 24 elemental species and baghouse performance was evaluated for overall removal efficiency, size fraction removal efficiency, and for selective removal of specific metals. Total concentrations of each element in the controlled emission stream was determined as well as the proportionate concentrations of species in the solid and volatile states. Concentrations of each metal in the emission stream was compared with the concentrations in a sludge residue.

To obtain comparisons of baghouse performance with a more typical emission control device, the performance of the incinerator's full scale wet scrubber was also evaluated.

The baghouse was considerably more efficient than the wet scrubber system, removing 99.1% of the uncontrolled emissions compared to 94.3% for the wet scrubber. The baghouse was more effective than the scrubber in removing particles smaller than 1 μm. Collection of volatile metals such as cadmium, which are concentrated in fine particle fractions, were substantially improved. The wet scrubber was much more effective than the baghouse for removing sulfur.

This report was submitted in fulfillment of Contract No. 68-03-3148 by Radian Corporation under the sponsorship of the U. S. Environmental Protection Agency. This report covers the period April 10, 1984, to September 30, 1985, and work was completed as of September 30, 1985.

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UNIT CONVERSION FACTORS

cubic feet x 2.831685 E-02 = cubic meters (m^3)

degrees Fahrenheit. $t^{o}C = (t^{o}F - 32)/1.8$ = degrees Celsius (^{o}C)

feet x 3.048000 E-01 = meters (m)

gallons x 3.785412 E-03 = cubic meters (m^3)

inches x 2.540000 E-02 = meters (m)

pounds x 4.535924 E-01 = kilograms (kg)

pressure, inch of H_2O ($60^{o}F$) x 2.4884 E+02 = pascal (Pa)

pressure, inch of H_2O ($32^{o}F$) x 2.60932 E+01 = millimeter of Hg (mm Hg)

pressure, inch of Hg ($60^{o}F$) x 3.37685 E+03 = pascal (Pa)

square feet x 9.290304 E-02 = square meter (m^2)

SECTION 1

INTRODUCTION

TEST PROGRAM OBJECTIVES

The objective of this research project was to determine the total particulate and trace metals removal efficiency of a fabric filter (i.e., baghouse) installed on a multiple hearth incinerator burning sewage sludge. To accomplish this objective, a pilot-scale baghouse was installed on a multiple hearth incinerator at a municipal wastewater treatment plant. A slipstream of the exhaust gas from the incinerator (approximately 3 percent of the exhaust gas flow) was ducted to the pilot-scale baghouse. The remaining portion of the incinerator exhaust gas was ducted to the full-scale wet scrubber that normally treats the incinerator emissions. This provided an opportunity to compare the particulate and trace metal removal capabilities of the baghouse and the scrubber.

The field sampling program consisted of a set of six valid test runs. During each test run, particulate sampling of the uncontrolled emissions from the incinerator (baghouse inlet location) was performed simultaneously with particulate sampling of the controlled emissions from either the scrubber or the baghouse. Three test runs were performed on the baghouse, and three test runs were performed on the scrubber. Source Assessment Sampling System trains (i.e., SASS trains) were used for the particulate sampling. Particulate matter samples captured in the various SASS train size fractions were analyzed individually for metals content using Inductively Coupled Argon Plasma Spectroscopy (ICAP).

Samples of sludge feed, bottom ash, and baghouse dust were obtained for each test run and analyzed for metals using ICAP. Continuous monitoring of SO_2, NO_x, CO, CO_2, O_2, and total hydrocarbons was performed at the incinerator outlet location during each test run. Process data for the incinerator, scrubber, and baghouse were also obtained. Sampling for volatile organic emissions from the scrubber was performed during three test runs using a volatile organic sampling train (VOST). Data for the VOST tests are summarized in a separate report. The remainder of the data are summarized in this report.

PROCESS DESCRIPTION

This section describes the host facility, the multiple hearth sewage sludge incinerator, the wet scrubber system, and the mobile baghouse system.

Facility Description

The host plant is a 14 mgd wastewater treatment plant. Approximately 70 percent of the treatment plant influent is municipal wastewater, and the remaining 30 percent is industrial wastewater. A military installation near the plant is the primary industrial source of metals in the influent wastewater.

The treatment plant influent is processed as shown in Figure 1. Treatment steps include screening, grit removal, primary clarification, aeration, flocculation/secondary clarification, and disinfection with chlorine. Sludges are removed from both the primary and secondary clarifiers. The primary and secondary sludges are pumped to the solids processing system, which is shown in Figure 2. Primary sludge is thickened by chemical addition and gravity thickening, while secondary sludge is thickened by chemical addition and flotation thickening. The chemical thickening agents used at the host plant are aliphatic polyelectrolyte polymers. The thickened primary and secondary sludges are combined, after which they can either be sent to an anaerobic digestion unit for volume reduction and fuel gas production, or they can be sent directly to a sludge storage tank with no digestion.

Digested or undigested sludge is sent from the storage tank to the final dewatering system. The sludge is dewatered using aliphatic polyelectrolyte polymer addition followed by centrifugation. Dewatered sludge is transferred by belt conveyor from the centrifuges to the incinerators. During the scrubber and baghouse tests, only digested sludge was fired in the incinerator that was tested.

Incinerator Description

The plant operates two multiple hearth sewage sludge incinerators, designated by the plant as the No. 1 and No. 2 units. The incinerators are not operated simultaneously. Typically one of the incinerators burns sludge for 2-3 weeks, followed by a 7 to 10-day period of no burning. The alternate incinerator is generally used when the next "burn cycle" begins.

The No. 1 unit was tested in this program. It is a six-hearth incinerator designed by Envirotech with a sludge feed capacity of 3,400 kg/hr (7,500 lb/hr) wet sludge. Emissions from the incinerator are controlled by a cyclone/wet scrubber system consisting of two cyclones followed by a water quench unit, a venturi scrubber, and an impingement tray scrubber. A schematic diagram of the incinerator and wet scrubber system is shown in Figure 3.

Digested dewatered sludge burned in the incinerator typically has a dry solids content of approximately 16 to 17 percent solids by weight. The volatiles content of the dry solids is approximately 70 percent by weight. The heating value and moisture content of the sludge do not allow for autogenous burning. Gas produced by the anaerobic digester and No. 2 fuel oil are burned in the incinerator as supplemental fuel. The auxiliary fuel firing rates are adjusted to maintain the desired temperature profile within the incinerator.

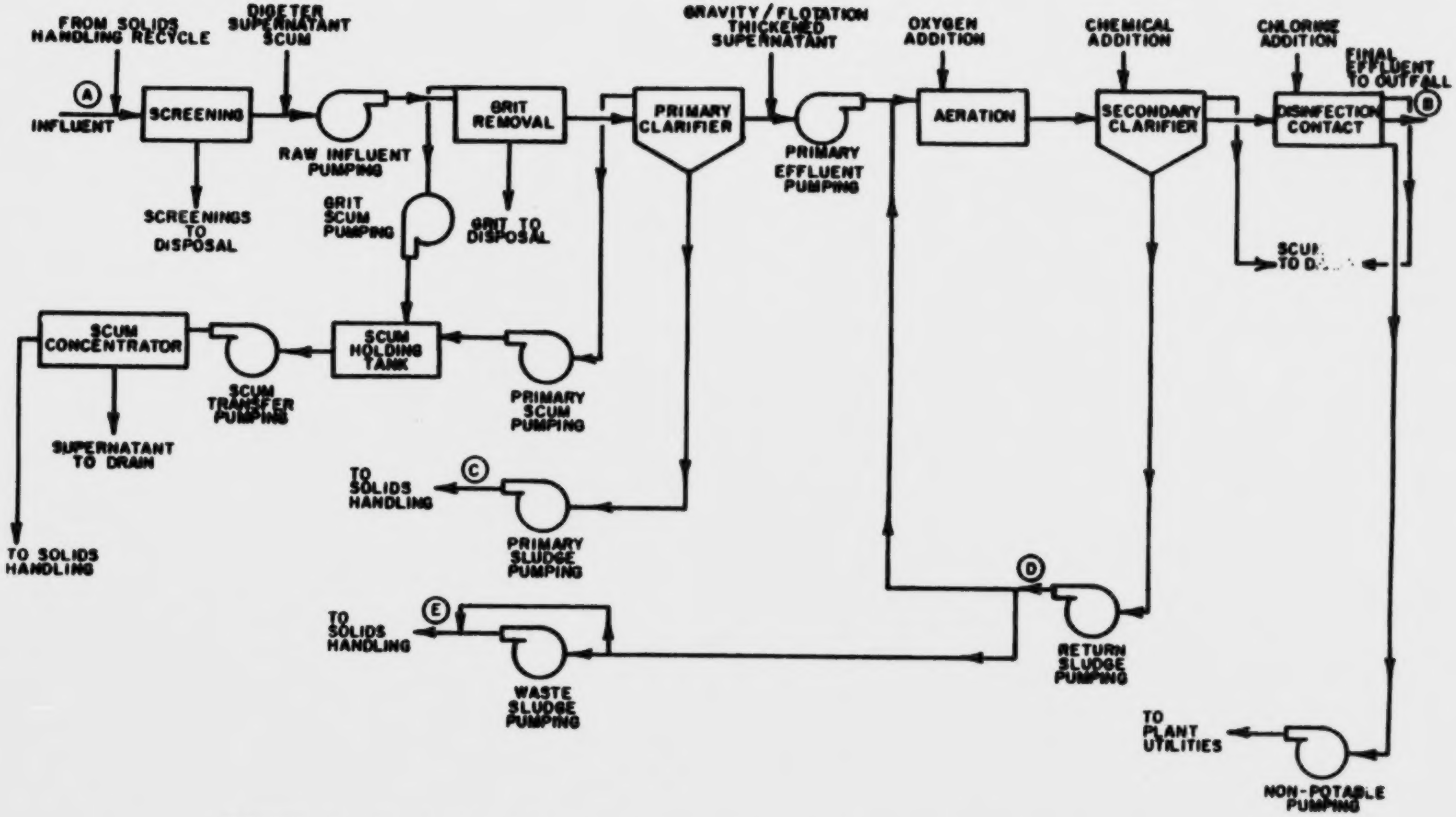
FROM SOLIDS HANDLING RECYCLE
A
INFLUENT
SCREENING
SCREENINGS TO DISPOSAL
DIGETER SUPERNATANT SCUM
RAW INFLUENT PUMPING
GRIT SCUM PUMPING
GRIT REMOVAL
GRIT TO DISPOSAL
PRIMARY CLARIFIER
GRAVITY/FLOTATION THICKENED SUPERNATANT
PRIMARY EFFLUENT PUMPING
OXYGEN ADDITION
AERATION
CHEMICAL ADDITION
SECONDARY CLARIFIER
CHLORINE ADDITION
DISINFECTION CONTACT
FINAL EFFLUENT TO OUTFALL
B
SCUM TO D
SCUM CONCENTRATOR
SUPERNATANT TO DRAIN
TO SOLIDS HANDLING
SCUM TRANSFER PUMPING
SCUM HOLDING TANK
PRIMARY SCUM PUMPING
TO SOLIDS HANDLING
C
PRIMARY SLUDGE PUMPING
D
RETURN SLUDGE PUMPING
TO SOLIDS HANDLING
E
WASTE SLUDGE PUMPING
TO PLANT UTILITIES
NON-POTABLE PUMPING

Figure 1. Wastewater Treatment Flow Diagram for the Host Site

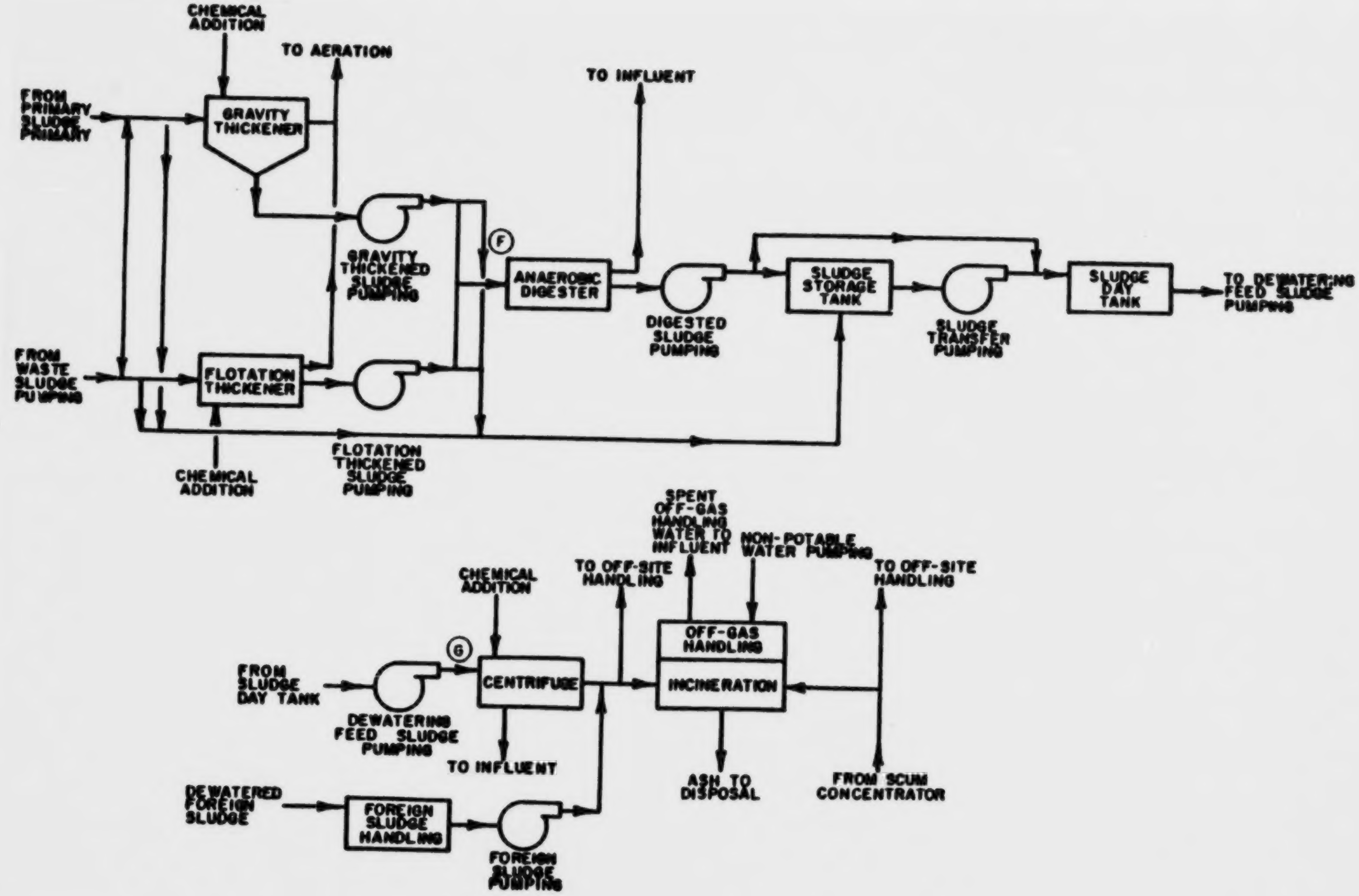
CHEMICAL ADDITION
TO AERATION
FROM PRIMARY SLUDGE PRIMARY
GRAVITY THICKENER
TO INFLUENT
GRAVITY THICKENED SLUDGE PUMPING
F
ANAEROBIC DIGESTER
DIGESTED SLUDGE PUMPING
SLUDGE STORAGE TANK
SLUDGE TRANSFER PUMPING
SLUDGE DAY TANK
TO DEWATERING FEED SLUDGE PUMPING
FROM WASTE SLUDGE PUMPING
FLOTATION THICKENER
CHEMICAL ADDITION
FLOTATION THICKENED SLUDGE PUMPING
SPENT OFF-GAS HANDLING WATER TO INFLUENT
NON-POTABLE WATER PUMPING
CHEMICAL ADDITION
TO OFF-SITE HANDLING
TO OFF-SITE HANDLING
FROM SLUDGE DAY TANK
G
CENTRIFUGE
OFF-GAS HANDLING
INCINERATION
DEWATERING FEED SLUDGE PUMPING
TO INFLUENT
ASH TO DISPOSAL
FROM SCUM CONCENTRATOR
DEWATERED FOREIGN SLUDGE
FOREIGN SLUDGE HANDLING
FOREIGN SLUDGE PUMPING

Figure 2. Solids Processing Flow Diagram for the Host Site

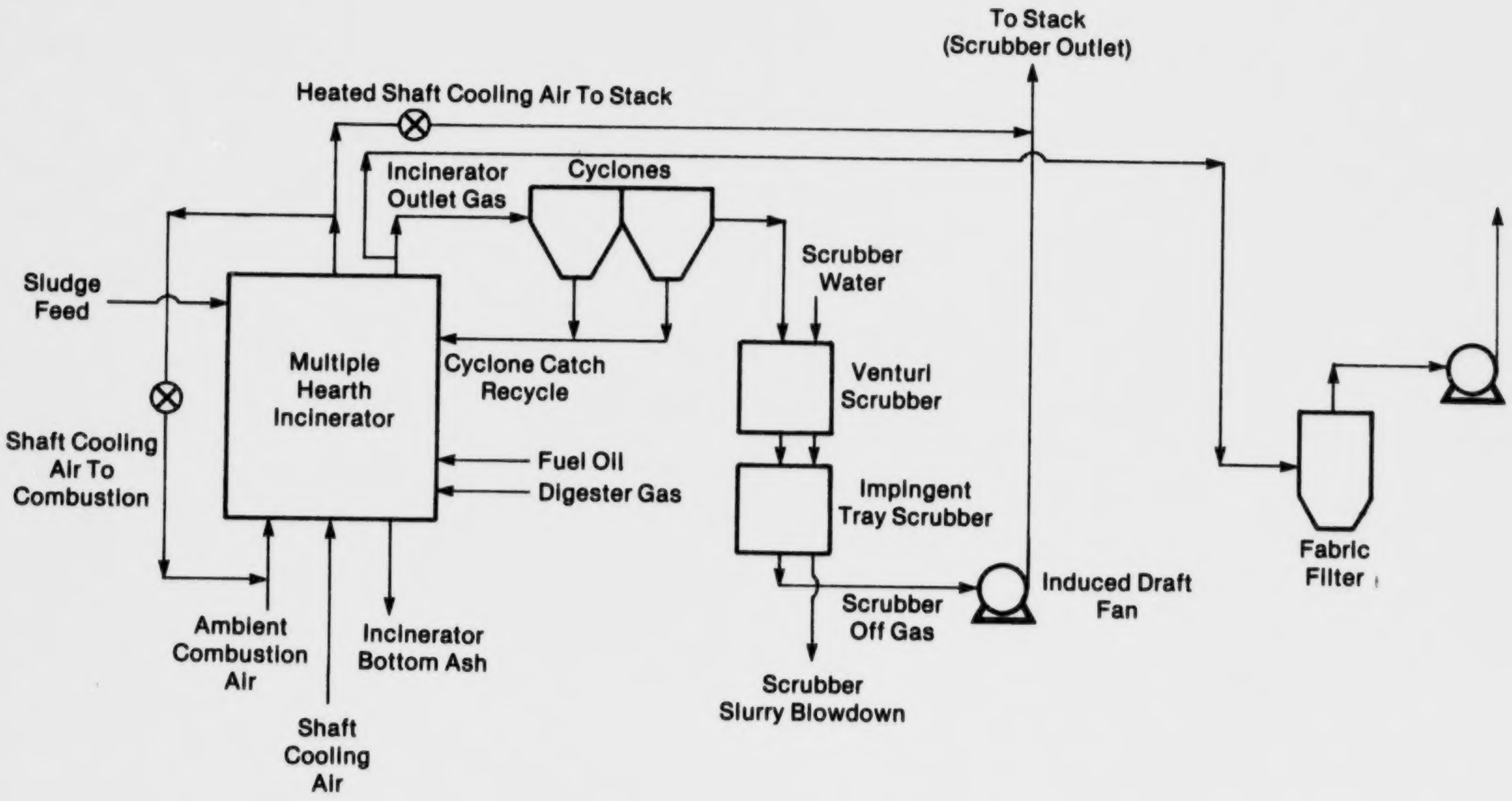
To Stack
(Scrubber Outlet)
Heated Shaft Cooling Air To Stack
Incinerator Outlet Gas
Cyclones
Sludge Feed
Multiple Hearth Incinerator
Cyclone Catch Recycle
Scrubber Water
Venturi Scrubber
Shaft Cooling Air To Combustion
Fuel Oil
Digester Gas
Impingent Tray Scrubber
Fabric Filter
Induced Draft Fan
Scrubber Off Gas
Ambient Combustion Air
Incinerator Bottom Ash
Scrubber Slurry Blowdown
Shaft Cooling Air

Figure 3. Schematic Diagram of the Incinerator System

The target temperature for the gas leaving the upper hearth (Hearth No. 1) is 380°C (720°F), with a range of 315 to 480°C (600 to 900°F). The sludge combustion zone is normally maintained on Hearth No. 3.

Combustion air fed to the incinerator can be either at ambient temperature or a preheated temperature, depending on operator preference. The preheated combustion air is supplied by recycling a portion of the heated air leaving the rabble arm shaft cooling air system. The design flow of the shaft cooling air is approximately 140 scmm (5,000 scfm). During the test program, all shaft cooling air was vented out the stack. All combustion air fed to the incinerator was ambient air supplied by a forced draft fan. The total amount of combustion air fed to the incinerator varies with fuel flow rate, opacity limitations, furnace draft, and other operating parameters. According to plant personnel, the oxygen content of the flue gas at the incinerator outlet (i.e., furnace breeching) is 13 to 17 percent O_2 (wet basis) as measured by plant monitoring equipment. Lower excess air levels are not achievable because of the onset of significant opacity when the oxygen content is less than 13 to 17 percent O_2. The plant normally maintains an in-situ flue gas oxygen analyzer at the furnace breeching, but this instrument was not operating during the test program. The incinerator is limited to 20 percent opacity by the Federal New Source Performance Standards (NSPS) for sewage sludge incinerators. Furnace draft at the breeching outlet is maintained at approximately -0.04 kPa (-0.15 in H_2O).

Bottom ash produced by the incinerator is screw conveyed out of the incinerator into a bucket elevator, which carries the ash about 40 feet vertically. The ash is then screw conveyed to a large hopper that is used for intermediate storage prior to disposal. Design specifications for the incinerator indicate that approximately 250 kg/hr (550 lb/hr) of bottom ash are produced when the sludge feed rate to the incinerator is 3,400 kg/hr (7,500 lb/hr) wet sludge. Incinerator operating data monitored regularly by the host plant include the wet sludge feed rate (lb/hr), flue gas oxygen content at the furnace outlet (% O_2, wet), draft at the furnace outlet (in. H_2O), individual hearth temperatures (°F), and shaft cooling air outlet temperature (°F). In addition, the host plant performs moisture and volatiles content analyses on a composite sludge sample for each day. The sample is a composite of 24 hourly samples taken off the sludge feed belt.

Emission Control System Description

Emissions from the tested incinerator are controlled by two cyclones in series with a water quench unit, a venturi scrubber, and an impingement tray scrubber. Plant measurements indicate that the cyclones capture about 3.5 kg of particulate matter per 1,000 kg of dry solids fed to the incinerator. The particulate matter captured by the cyclones is screw conveyed directly back into the incinerator.

Exhaust gases from the cyclones pass through a water spray cooling section in the ductwork and are then sent to the venturi and impingement tray scrubbers. The spray cooling water, venturi scrubber water, and impingement tray scrubber water consist of sewage treatment plant effluent that is used once in the scrubber system and sent back to the treatment plant after use. The scrubber system uses a total of approximately 4,500 m^3 (1.2 million gallons) of treatment plant effluent per day. Approximately two-thirds of this water is added to the impingement tray scrubber, and most of the remainder is added to the venturi scrubber. The spray cooler preceding the venturi scrubber and another spray cooler preceding the impingement tray scrubber use about 7 percent of the total scrubber system water. The overall ratio of scrubber water to incinerator exhaust gas (i.e., liquid-to-gas ratio) is approximately 0.025 m^3 water/dscm exhaust gas (0.2 gal/dscf). Pressure drops across the venturi and impingement tray scrubbers are typically 28mm Hg and 9mm Hg (15 in H_2O and 5 in H_2O), respectively. Exhaust gas exits the scrubber system at a temperature of approximately 27°C (80°F). The exhaust gas is pulled through an induced draft (ID) fan, combined with any shaft cooling air that is not used as preheated combustion air, and sent out a stack. The current rated capacity of the ID fan is 190 acmm at 54°C and 84mm Hg (6,800 acfm at 160°F and 45 in H_2O).

The scrubber operating data include venturi scrubber and impingement tray scrubber pressure drops (in H_2O), venturi scrubber inlet gas temperature (°F), and ID fan inlet temperature (°F). Because of the proximity of the ID fan to the impingement tray scrubber outlet, the ID fan inlet temperature is essentially the same as the impingement tray scrubber outlet temperature.

MOBILE BAGHOUSE SYSTEM

Mobile Baghouse Description

Original Mobile Baghouse Design. The mobile baghouse used in the test program was originally designed to collect bulk quantities of combustion particulate under low mass loading conditions. The original configuration of the baghouse system is shown in Figure 4. Construction details are described in reference 1. The system was designed to accept a slipstream from an exhaust stack through a 3" DIA pipe. The slipstream was to be mixed with filtered dilution air, passed through the baghouse, and discharged to a small stack through an ID fan. SASS train sampling ports were provided at the baghouse inlet location, but no sampling ports were provided at the baghouse outlet location.

The baghouse was designed to hold up to 20 envelope-type filter bags. The dimensions of the filter bags that fit the unit are 19.75 in. x 21.5 in., with an effective collection area of 5.9 sq ft per bag. Goretex teflon B/fiberglass bags were specified with the original design. Wire mesh is used to internally support the bags, which were originally designed to be cleaned by mechanical shaking. The mechanical shaking was to be provided by a rotating metal bar that strikes the bottoms of the bags as it is rotated. As will be discussed in Section 2.1.3, the mechanical shaker mechanism was found to be ineffective at removing the incinerator particulate from the bag surface. Bag cleaning was performed manually after each test run using a soft brush.

A 4 liter glass jar at the base of the baghouse is used for particulate recovery. A limited degree of temperature control is provided by heating elements that wrap around the exterior surface of the baghouse.

Modifications to the Original Design. The mobile baghouse system described in Reference 1 was modified for the purpose of this sampling program. Figure 5 is a schematic diagram of the modified system. The

ORIGINAL DESIGN BAGHOUSE/DILUTION SYSTEM

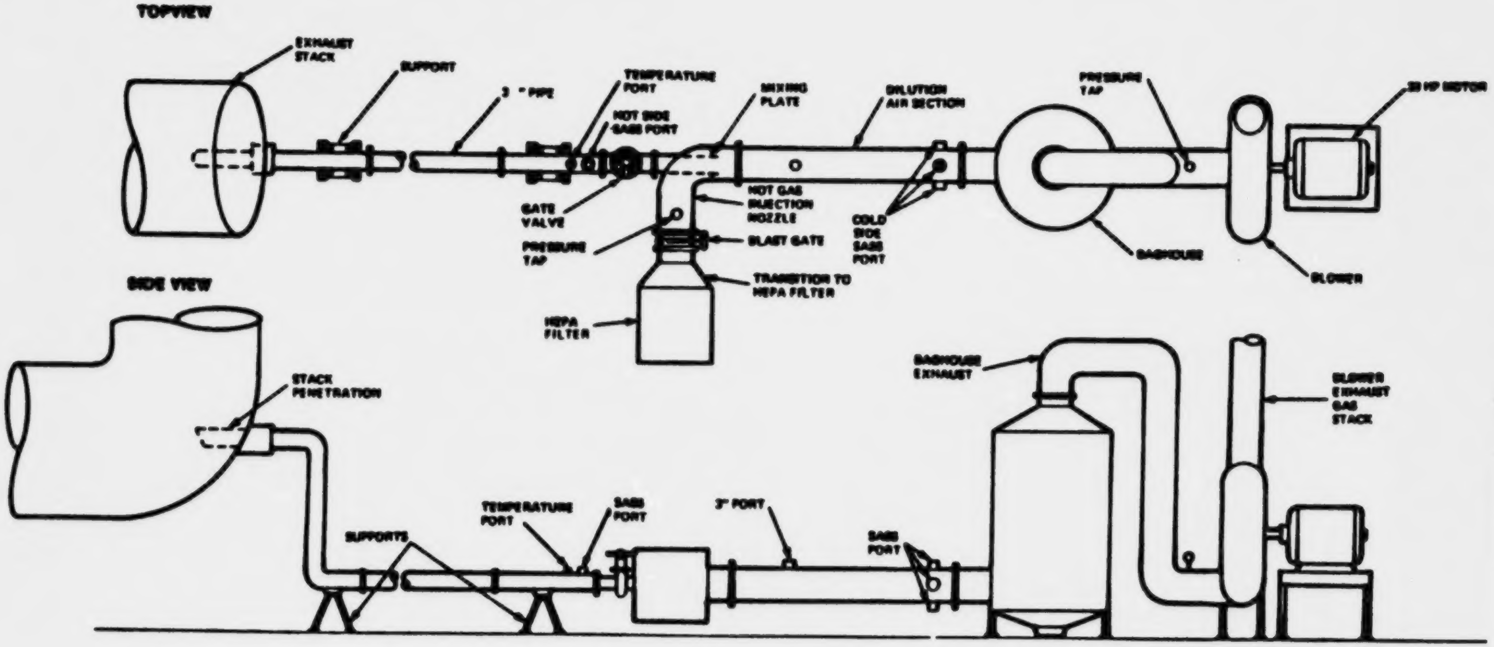
TOPVIEW
EXHAUST STACK
SUPPORT
3 " PIPE
TEMPERATURE PORT
HOT SIDE SASS PORT
GATE VALVE
PRESSURE TAP
MIXING PLATE
HOT GAS INJECTION NOZZLE
BLAST GATE
TRANSITION TO HEPA FILTER
HEPA FILTER
DILUTION AIR SECTION
COLD SIDE SASS PORT
PRESSURE TAP
BAGHOUSE
BLOWER
20 HP MOTOR
SIDE VIEW
STACK PENETRATION
SUPPORTS
TEMPERATURE PORT
SASS PORT
3" PORT
SASS PORT
BAGHOUSE EXHAUST
BLOWER EXHAUST GAS STACK

Figure 4. Original design of mobile baghouse/dilution system

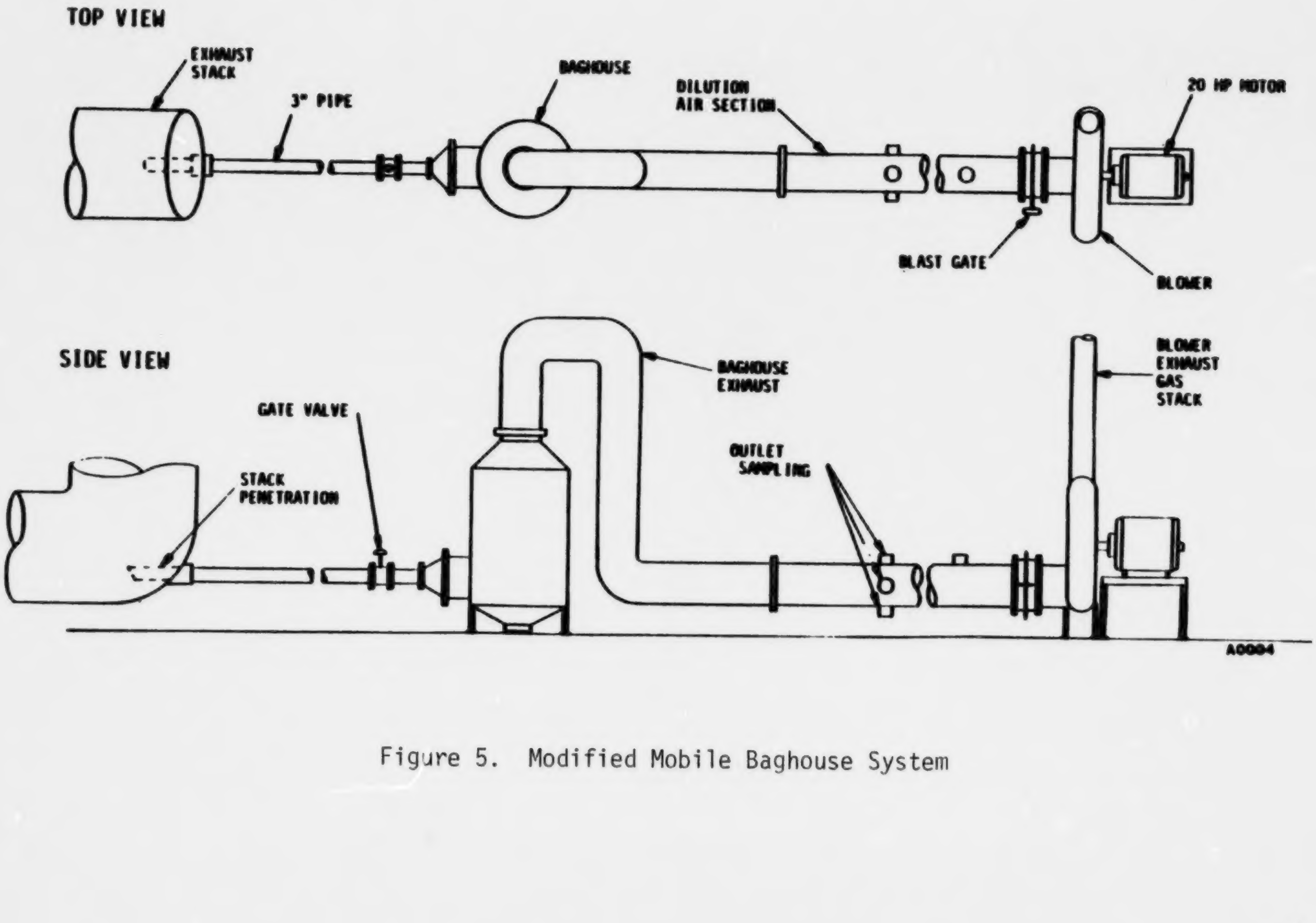
TOP VIEW
EXHAUST STACK
3" PIPE
BAGHOUSE
DILUTION AIR SECTION
20 HP MOTOR
BLAST GATE
BLOWER
SIDE VIEW
GATE VALVE
STACK PENETRATION
BAGHOUSE EXHAUST
OUTLET SAMPLING
BLOWER EXHAUST GAS STACK
A0004

Figure 5. Modified Mobile Baghouse System

"dilution air" section containing the SASS sampling ports was moved from the baghouse inlet location to the baghouse outlet location, and the HEPA dilution air filter was omitted from the system.

As modified for this program, the baghouse was capable of accepting a slipstream of the sewage sludge incinerator exhaust gas through 3" DIA pipe. The capacity of the baghouse (number of bags) was reduced from the maximum original capacity of 20 bags to a capacity of 10 bags. Alternate slots in the bag holder grating were covered with thin metal strips. This was done to increase the amount of free space between bags, thereby minimizing the potential for blockage between bags.

Desired Baghouse Operating Parameters. Target baghouse operating parameters were selected to be representative of expected operating conditions of a full scale baghouse installed on a multiple hearth incinerator. Although there are no existing baghouse installations on multiple hearth sewage sludge incinerators in the United States, one installation is planned in 1985 for a proposed fluidized bed sewage sludge incinerator in California. Consultation with the filter bag vendor for the planned installation indicated that the design air:cloth ratio is 4:1 (4 acfm per sq ft bag collection area) and the design operating temperature is 400°F. The filter bag material to be used in the planned installation is a Goretex membrane/Goretex (PTFE) fabric.

The target mobile baghouse operating parameters during the test runs were:

(i) air:cloth ratio of approximately 4:1 (acfm:sq ft)
(ii) temperature of approximately 400°F

The filter bag material selected for the test program was a Goretex membrane/Nomex felt filter laminate. This material was selected because of the superior surface cleaning characteristics of the Goretex membrane and because of the physical strength characteristics of the Nomex felt backing. A strong backing material was chosen to accommodate the shaker cleaning mechanism. According to the vendor, the Goretex membrane/Nomex felt filter laminate can be designed for continuous operating temperatures of 400°F and can withstand excursions up to 425°F. The target pressure drop range for the baghouse was 0-10 inches of water.

Mobile Baghouse/Multiple Hearth Incinerator Interface

A schematic diagram of the ductwork system from the slipstream sampling point at the incinerator breeching to the mobile baghouse system is shown in Figure 6. The ductwork system consisted of a 316 stainless steel sample "nozzle" that was sized to obtain a representative slipstream from the incinerator exhaust stream; a horizontal section of 3" DIA carbon steel pipe to transport the sample from the incinerator breeching to a point outside the incinerator building; a vertical section of 3" and 8" DIA carbon steel pipe to transport the sample down to grade level and to provide inlet sampling ports; and a horizontal section of 3" DIA carbon steel pipe to transport the sample to the mobile baghouse. Figures 7 show side and top views of the ductwork, flanges, sampling ports, and valves.

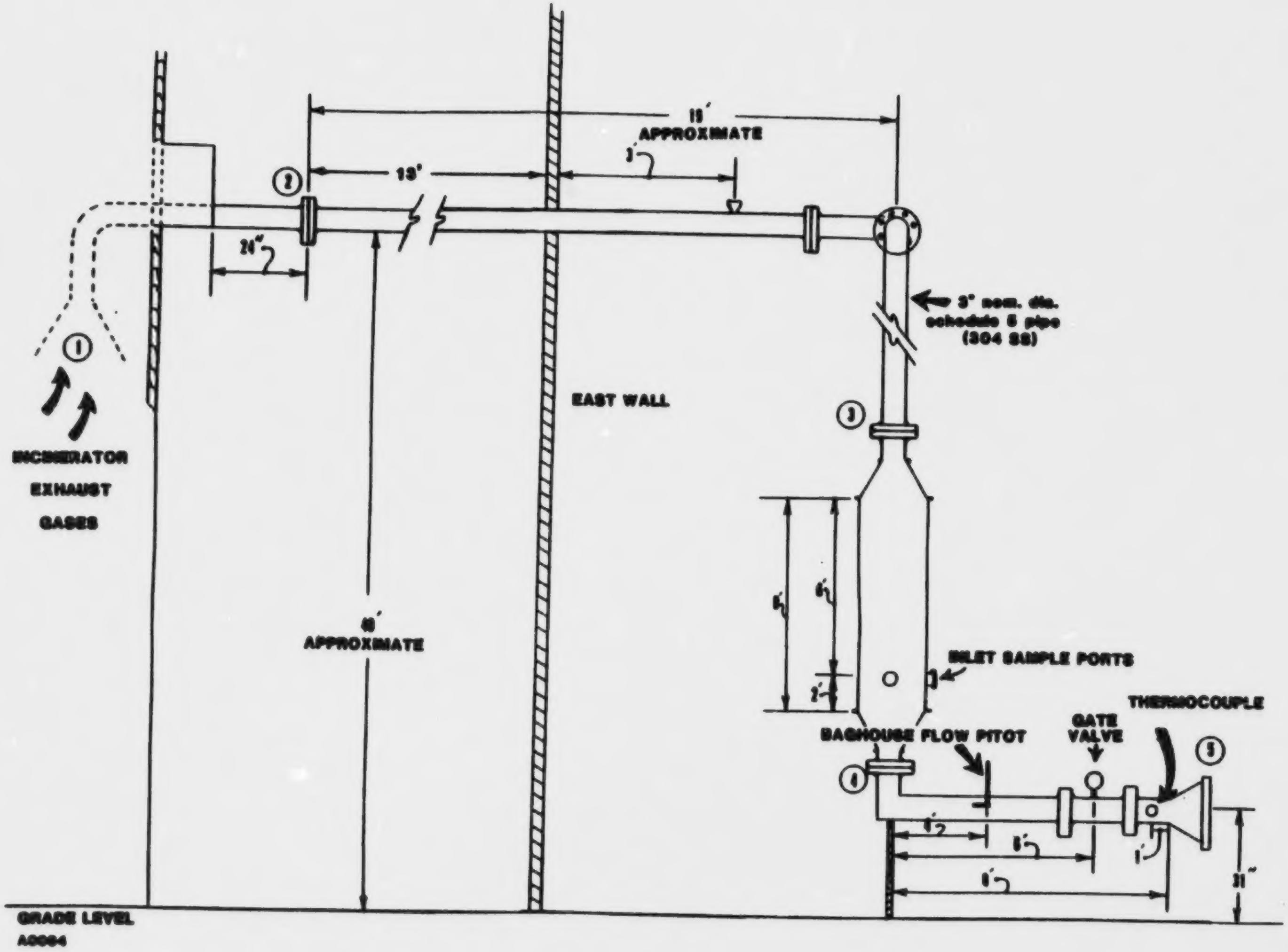
INCINERATOR EXHAUST GASES
①
②
③
④
⑤
24"
13'
19'
APPROXIMATE
3'
APPROXIMATE
EAST WALL
3" nom. dia. schedule 5 pipe (304 SS)
INLET SAMPLE PORTS
2'
BAGHOUSE
FLOW PITOT
GATE VALVE
THERMOCOUPLE
1'
31"
GRADE LEVEL
A0094

Figure 6. Slipstream Ductwork System

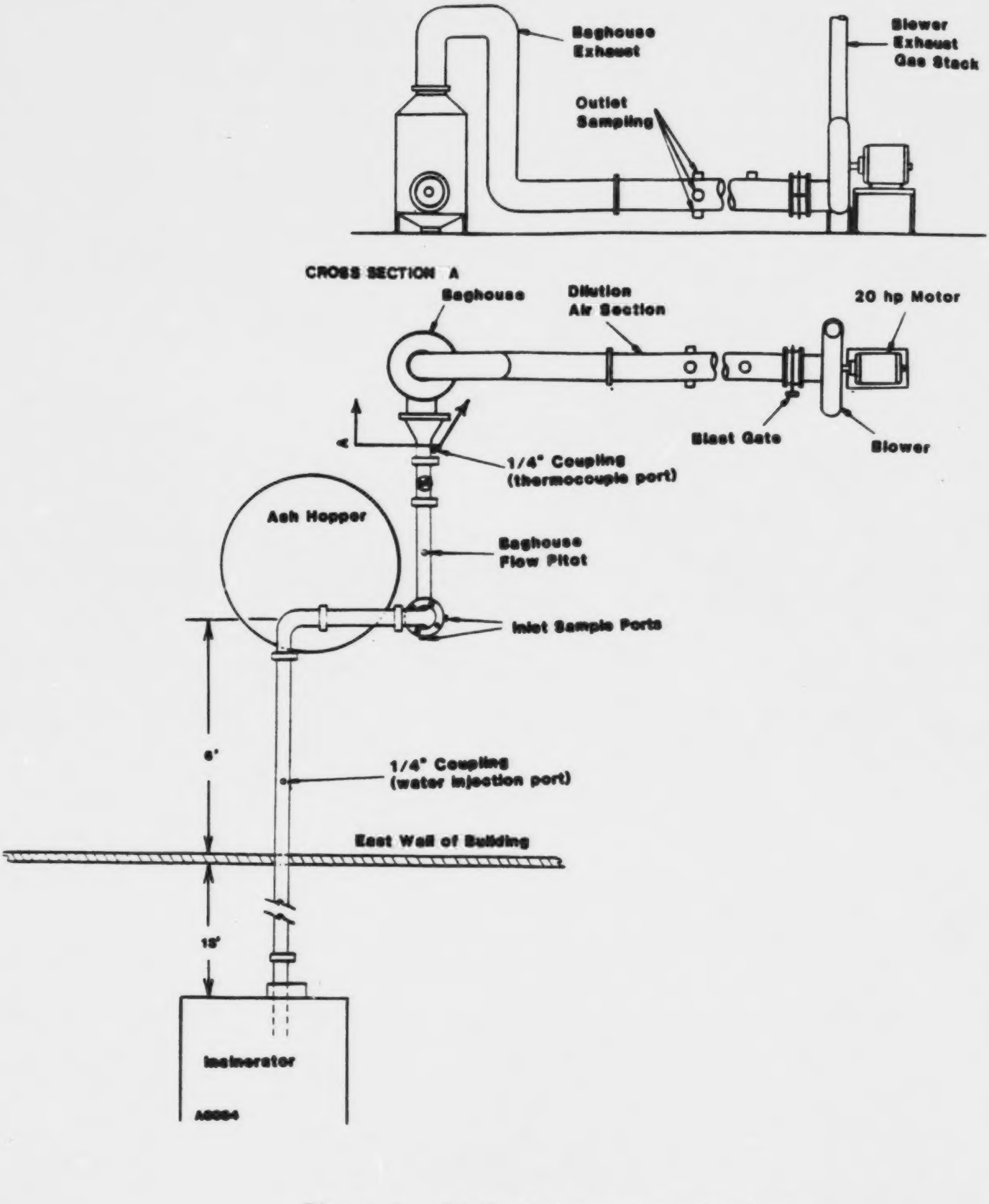
Baghouse Exhaust
Blower Exhaust Gas Stack
Outlet Sampling
CROSS SECTION A
Baghouse
Dilution Air Section
20 hp Motor
Blast Gate
Blower
1/4" Coupling (thermocouple port)
Ash Hopper
Baghouse Flow Pitot
Inlet Sample Ports
8'
1/4" Coupling (water injection port)
East Wall of Building
13'
Incinerator
A8084

Figure 7. Mobile Baghouse Installation

The ductwork system was designed to achieve four major objectives: (i) to obtain a representative sample of the incinerator exhaust gas; (ii) to convey the particulate matter in the gas to the baghouse without particle fallout; (iii) to maintain the baghouse inlet gas at the appropriate temperature; and (iv) to provide adequate sampling ports for baghouse inlet sampling. To achieve these objectives, the following design criteria were implemented: (i) the slipstream nozzle was sized and placed in the incinerator breeching outlet to provide near-isokinetic slipstream sampling; (ii) the duct diameter was selected such that a linear gas velocity of at least 3500 ft/min was maintained at all points of the horizontal pipe sections; (iii) the duct length was designed to cool the gas below 400^{o}F, with removable insulation used to "fine tune" the baghouse inlet gas temperature; and (iv) a vertical section of 8" DIA pipe was installed to accommodate baghouse inlet sampling ports.

The slipstream nozzle design and placement in the duct were the most critical aspects of the ductwork system design. A preliminary velocity traverse was first performed at the incinerator outlet location to characterize the velocity profile of the incinerator exhaust gas. The measured volumetric flow rate of the incinerator exhaust gas was approximately 14,000 acfm @ 836^{o}F. The velocity profile in the duct was found to be relatively uniform, with an average gas velocity of 1700 fpm (actual stack conditions).

The slipstream nozzle was sized to provide 236 acfm @ 400^{o}F of inlet gas to the baghouse under conditions of isokinetic slipstream sampling. This corresponded to an air to cloth ratio of 4 acfm/ft^2 at the baghouse. The design nozzle size was calculated as follows:

$$A_n = Q_s/\underline{v}_i$$

where A_n = required nozzle area

Q_s = desired slipstream volume, corrected to the average incinerator outlet temperature

$\underline{v}_i$ = measured average incinerator outlet gas velocity

Substituting the preliminary velocity traverse data into the above relation yielded a design nozzle diameter of 6.2 inches.

The slipstream nozzle was custom fabricated from 316 stainless steel. Because of the uniformity of the velocity profile, the nozzle was placed in the center of the incinerator outlet duct. An inspection of the slipstream nozzle at the end of the test program showed that the stainless steel surface was smooth. There was no evidence of nozzle corrosion from contact with the incinerator exhaust gas.

Distribution of Incinerator Exhaust Gas Flow to Scrubber and Baghouse

The approximate distribution of the incinerator exhaust gas flow to the scrubber system and the mobile baghouse is shown in Figure 8. The average incinerator exhaust gas flow rate during the test runs was 90 dscmm.

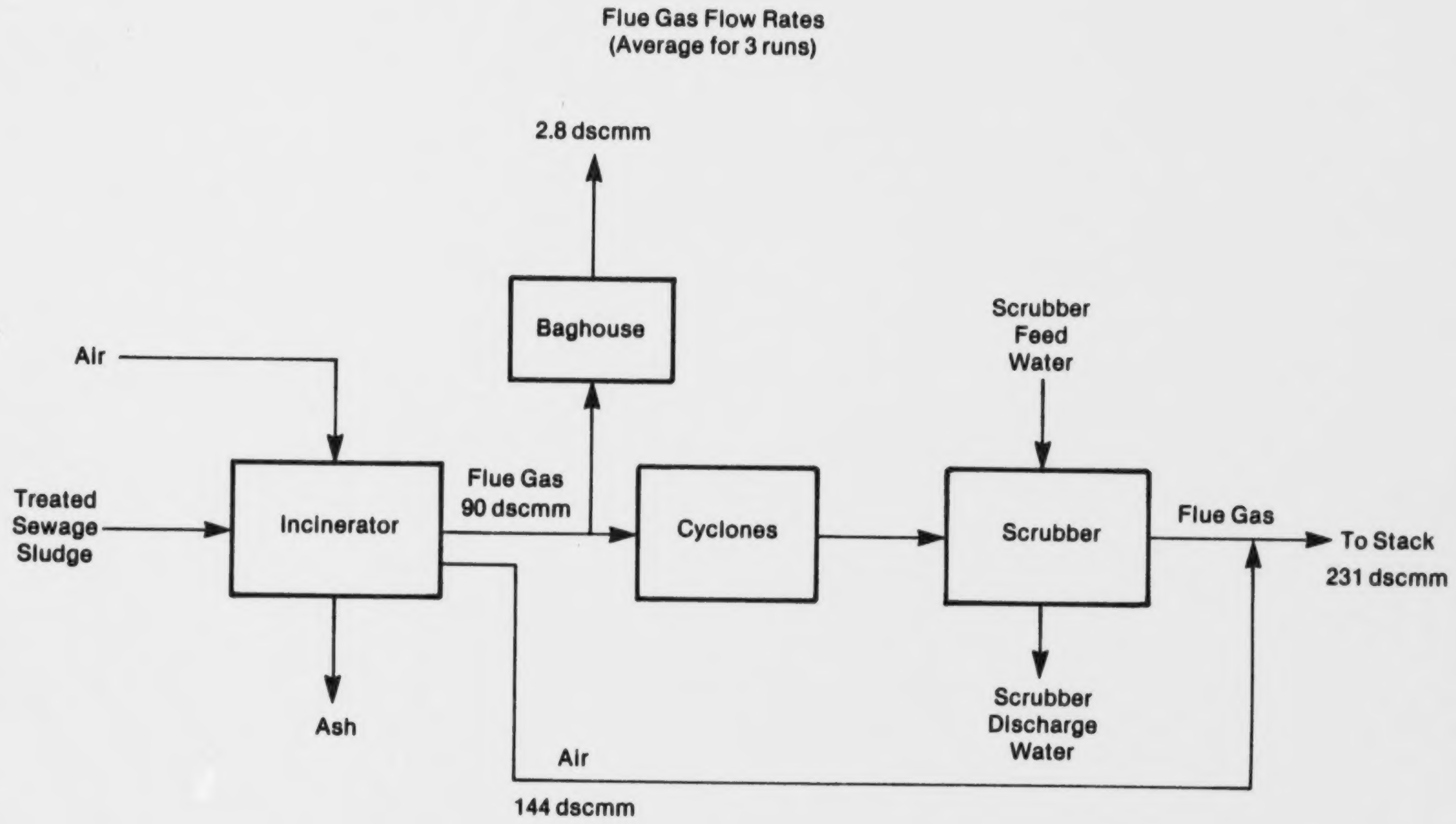
Flue Gas Flow Rates
(Average for 3 runs)
2.8 dscmm
Baghouse
Air
Treated Sewage Sludge
Incinerator
Ash
Flue Gas
90 dscmm
Cyclones
Scrubber Feed Water
Scrubber
Scrubber Discharge Water
Flue Gas
To Stack
231 dscmm
Air
144 dscmm

Figure 8. Distribution of Incinerator Exhaust Gas Between the Scrubber and Baghouse

Approximately 3 percent of this flow (2.8 dscmm) was diverted to the baghouse slipstream, and the remaining 97 percent (87 dscmm) went to the wet scrubber system. Based on these flow rate data, it is concluded that the scrubber operation was not significantly affected by the presence of the slipstream.

The average stack gas flow rate during the tests was 231 dscmm. Approximately 40 percent of this flow (87 dscmm) was accounted for by scrubber offgas, and the remaining 60 percent (144 dscmm) was accounted for by shaft cooling air.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The investigation established the superior performance of the baghouse over the scrubber for total particle removal. Particle removal efficiency for the baghouse, based on removal of uncontrolled emissions by the collection device, averaged 99.1%, which was much greater than the average efficiency of 94.3% achieved with the incinerator's wet scrubbing system. Removal efficiencies for the larger size fractions in the SASS train were about the same for both air pollution control devices. However, for the smallest size fraction, the filter catch (<1.0 μm), the baghouse removal efficiency averaged 98.6% compared to 59.1% for the wet scrubbing system. The superior performance of the baghouse can thus be attributed to its ability to efficiently remove fine particles.

Uncontrolled particulate emissions showed substantial enrichment for three metals: cadmium, lead, and tin. These metals also were present in unusually high proportion in the finest fraction (<1 μm). Evidently these metals volatilize during combustion and condense to fine particles or are adsorbed on the finest particles leaving the incinerator.

Trace metal removal efficiencies for the baghouse and the scrubber for several metals, including lead and chromium could not be determined because contamination of some of the particle size fractions. For cadmium, removal efficiency averaged 82 percent for the wet scrubbing system and 98.5 percent for the baghouse. Efficiency was low for the wet scrubber because the scrubber efficiency was low for the filter catch fraction (<1 μm) and most of the cadmium was in this fraction.

The enrichment ratio for cadmium increased from 25.6 for uncontrolled emissions to 75.4 at the scrubber outlet and to 47.1 at the baghouse outlet. The concentration of cadmium in the finest fraction combined with poor collection efficiency for the finest fraction, accounts for the large increase in enrichment ratio for the scrubber. The increase is not as large for the baghouse because collection efficiency for the finest fraction is only slightly lower than for the other fractions.

The scrubber showed a 99% removal for sulfur whereas the baghouse removed very little sulfur. If SO_2 removal is important, a baghouse would have to be preceded or followed by at least a low pressure drop wet scrubber.

Visual observation showed a colored plume, indicating significant organic emission, and condensation of an oily layer on surfaces.

RECOMMENDATIONS

The presence of an unburned hydrocarbon plume in the flue gas and "early volatiles" on the baghouse dust indicates the presence of oily materials that could cause fouling of filter. Use of an afterburner would eliminate this problem. If an afterburner is not provided, a long term test to determine whether intolerable bag fouling would occur is advised before using a baghouse to control emissions from a multiple hearth furnace burning sewage sludge.

The baghouse emissions and the wet scrubber emissions were not determined simultaneously primarily because of unavailability of sufficient staff. Although the composition of feed and uncontrolled emissions as well as other operating parameters were determined for both baghouse and scrubber runs, interpretation would have been more straightforward if both devices were fed with the identical uncontrolled emission stream. In future work, comparisons should be conducted simultaneously.

SECTION 3

PRESENTATION OF RESULTS

This section presents the results of the test program. Data are reported for six test runs. Runs 02 to 04 are the scrubber test runs, and Runs 06 to 08 are the baghouse test runs.

Process data characterizing the operation of the incinerator, scrubber, and baghouse are contained in following section (Process Data). Emissions data of total particulate and trace metals, including removal performance of the emissions control units, are described in the next sections (Total Particulate Emissions Data and Trace Metals Emissions Data). The next section (Comparison of Scrubber and Baghouse Performance) discusses the relative performance of the baghouse and the scrubber. Metals content of bottom ash and baghouse dust are then reported (Trace Metals Content of Bottom Ash and Baghouse Dust) followed by the results of continuous monitoring of the exhaust gas (Continuous Monitoring Data). The last section presents dispersion modeling parameters for the scrubber and for a hypothetical full scale baghouse.

PROCESS DATA

Incinerator Operating Data

Data summarizing the operation of the multiple hearth sewage sludge incinerator during the scrubber test runs and the baghouse test runs are shown in Tables 1 and 2, respectively. The data show that, in general, the incinerator was operated similarly during the test runs.

The total solids content and volatile solids content of the sludge were fairly consistent between test runs. The total dry solids content of the sludge as measured by the host plant ranged from 14.1 to 16.8 weight percent, with an average of 15.8 weight percent. Volatile solids accounted for approximately 69 weight percent of the total dry solids, with non-volatile solids accounting for the remaining 31 weight percent.

Feed rates to the incinerator ranged from 3270 to 4150 lb/hr wet sludge, with an overall average feed rate of 3880 lb/hr. The maximum deviation of the mean wet sludge feed rate for any run from the average value for all runs was approximately 16 percent (Run 03).

Mean incinerator hearth temperatures during the scrubber test runs and the baghouse test runs are shown in Tables 3 and 4, respectively. The data show that the hearth temperatures were similar between runs, with the maximum between-run temperature variability for any hearth being 118^{o}F (Hearth 1, Runs 02 and 08). The main flame zone during all test runs was on Hearth 3, which exhibited the highest temperature in the furnace. The average temperature of Hearth 3 for all test runs was 1391^{o}F, with the maximum variability between any two test runs being 42^{o}F.

TABLE 1. MEAN INCINERATOR OPERATING PARAMETERS DURING THE SCRUBBER TEST RUNS (PLANT DATA)

Parameter	Run 02	Run 03	Run 04	Average
Sludge Feed Rate (lb/hr)				
Wet Cake	4110	3270	3750	3710
Dry Cake	625	461	593	560
Residue at 600°C	181	138	172	164
Sludge Composition (wt. %)				
Moisture	84.6	85.9	84.2[a]	85.0
Dry Solids	15.2	14.1	15.8[a]	15.0
Volatile Matter	71	70	71	71
Excess Oxygen (% vol, dry)[b]	11.3	12.2	13.0	12.2
Auxiliary Fuel Usage				
Fuel Gas (cu ft/hr)	150	0	0	50
Fuel Oil (gal/hr)	34	29	29	31

[a] Sludge moisture and solids content data for Run 04 were taken as the average for all test runs.

[b] Excess oxygen data were developed by Radian using integrated bag sampling at the incinerator outlet location.

TABLE 2. MEAN INCINERATOR OPERATING PARAMETERS DURING THE BAGHOUSE TEST RUNS (PLANT DATA)

Parameter	Run 06	Run 07	Run 08	Average
Sludge Feed Rate (lb/hr)				
Wet Cake	4000	4000	4150	4050
Dry Cake	660	664	697	674
Residue at 600°C	205	212	223	213
Sludge Composition (wt. %)				
Moisture	83.5	83.4	83.2	83.4
Dry Solids	16.5	16.6	16.8	16.6
Volatile Matter	69	68	68	68
Excess Oxygen (% vol, dry)[a]	13.9	15.3	13.7	14.3
Auxiliary Fuel Usage				
Fuel Gas (cu ft/hr)	1800	3900	3000	3000
Fuel Oil (gal/hr)	23.1	8.0	10.0	13.7

[a] Excess oxygen data were developed by Radian using integrated bag sampling at the incinerator outlet location.

TABLE 3. MEAN HEARTH TEMPERATURES DURING THE SCRUBBER TEST RUNS (RUNS 02-04)

Hearth Number	Mean Hearth Temperature (^{o}F)[a]			
	Run 02	Run 03	Run 04	Average, Scrubber Tests
1	843	809	835	829
2	1088	1113	1063	1088
3	1415	1402	1378	1398
4	1038	1005	1024	1022
5	392	394	393	393
6	103	119	110	111

[a] To convert from ^{o}F to ^{o}C, use the formula $^{o}C = (^{o}F-32)/1.8$.

TABLE 4. MEAN HEARTH TEMPERATURES DURING THE BAGHOUSE TEST RUNS (RUNS 06-08)

Hearth Number	Mean Hearth Temperature (^{o}F)[a]			
	Run 06	Run 07	Run 08	Average, Baghouse Tests
1	773	742	725	747
2	1161	1158	1162	1160
3	1385	1395	1373	1384
4	1038	986	998	1005
5	399	362	368	376
6	110	119	116	112

[a] To convert from ^{o}F to ^{o}C, use the formula $^{o}C = (^{o}F-32)/1.8$.

Auxiliary fuel firing rates (i.e., digester gas, No. 2 fuel oil) were adjusted by plant personnel during the test runs to maintain the desired hearth temperature profile. During the scrubber test runs the average fuel oil firing rate was 31 gal/hr, with a range for the three test runs of 29 to 34 gal/hr. A small amount of digester gas was fired only during Run 02 (150 cu ft/hr) of the scrubber test runs. During the baghouse test runs, both fuel oil and digester gas were fired during all three test runs. The average fuel oil firing rate was 14 gal/hr, with a range for the three test runs of 8 to 23 gal/hr. The average digester gas firing rate was 3000 cu ft/hr, with a range for the three test runs of 1800 to 3900 cu ft/hr. The amount of fuel oil fired during a given run was inversely related to the amount of digester gas fired.

Metals Content of Sludge Feed. ICAP analyses of composite sludge feed samples from each test run are shown in Table 5. The data show that the concentrations of most metals in the sludge were fairly consistent between test runs. Calcium, magnesium, sodium, and aluminum showed the highest between-run variability, of the metals present in appreciable quantities. Selenium, silver, and gold also showed significant variability but these elements were present in very small quantities. The 24 species analyzed accounted for an average of 22.8 weight percent of the non-volatile solids fed to the incinerator.

In Table 6, the average results from the sludge analyses are compared with the typical metals content of sludge.[1] Results for fifteen of the twenty metals (for which typical concentrations were available) were within an order of magnitude of the typical concentration. For five metals (aluminum, arsenic, barium, chromium, and selenium), averages were within one to two orders of magnitude of the typical concentrations.

Scrubber Operating Data

Mean scrubber system operating data during the scrubber test runs are summarized in Table 7. The pressure drop data across the venturi scrubber and impingement tray scrubber showed that the scrubber system was operated steadily during the tests runs. The mean pressure drops across the venturi and impingement tray scrubbers were 20.2 and 5.0 in H_2O, respectively. Scrubber water flow rates were estimated by plant personnel based on previous measurements. Valve settings on the scrubber water supply system were not adjusted during the tests. The total estimated scrubber water flow of 807 gpm was distributed as follows: precooler, 33 gpm; venturi scrubber, 247 gpm,; impingement tray scrubber, 27 gpm; and impingement tray scrubber trays, 500 gpm. The calculated liquid to gas ratio based on estimates of the gas flow rate at the incinerator outlet was approximately 0.2 gal/dscf.

The inlet gas temperature to the wet scrubber system (i.e., Hearth 1 temperature) averaged 829°F, with a maximum deviation for any run of 20°F from the average. The outlet gas temperature from the wet scrubber system (i.e., ID fan inlet temperature) averaged 80°F and showed very little variability between test runs.

TABLE 5. ICAP ANALYSES OF THE SLUDGE FEED SAMPLES
(Dry, Volatiles Free Basis)

METAL	METALS CONTENT OF SLUDGE FEED PPM							
	RUN 3	RUN 4	RUN 6	RUN 7	RUN 8	AVERAGE	STD	REL STD
ALUMINUM	5.92E+02	5.93E+02	6.79E+02	2.39E+03	1.17E+03	1.09E+03	767.80	70.74
ANTIMONY	1.93E+02	2.17E+02	1.98E+02	2.24E+02	2.20E+02	2.10E+02	14.10	6.70
ARSENIC	6.04E+02	5.54E+02	5.34E+02	5.80E+02	5.98E+02	5.74E+02	29.63	5.16
BARIUM	5.86E+01	9.04E+01	6.38E+01	8.80E+01	1.16E+02	8.33E+01	23.01	27.62
CADMIUM	2.18E+02	2.37E+02	1.99E+02	2.38E+02	1.93E+02	2.17E+02	20.91	9.64
CALCIUM	5.48E+04	5.40E+04	5.03E+04	1.72E+04	3.22E+04	4.17E+04	16500.71	39.56
CHROMIUM	3.46E+02	3.87E+02	3.49E+02	3.71E+02	4.11E+02	3.73E+02	27.22	7.30
COBALT	3.57E+01	3.80E+01	2.94E+01	3.98E+01	3.66E+01	3.59E+01	3.96	11.03
COPPER	4.73E+03	4.57E+03	4.08E+03	4.87E+03	4.69E+03	4.59E+03	301.49	6.57
GOLD	5.34E+00	4.34E+00	3.60E+00	3.53E+00	0.00E+00	3.36E+00	2.02	59.98
IRON	6.48E+04	6.29E+04	5.25E+04	5.33E+04	5.59E+04	5.79E+04	5625.81	9.72
LEAD	6.25E+02	7.01E+02	6.02E+02	7.79E+02	6.96E+02	6.81E+02	69.81	10.26
MAGNESIUM	1.90E+04	2.08E+04	1.99E+04	8.32E+03	1.27E+04	1.61E+04	5408.43	33.49
MANGANESE	3.18E+02	3.26E+02	2.37E+02	3.17E+02	3.09E+02	3.01E+02	36.56	12.14
NICKEL	1.43E+02	1.88E+02	1.18E+02	1.56E+02	1.78E+02	1.57E+02	27.90	17.79
PHOSPHORUS	6.54E+04	5.85E+04	5.57E+04	6.46E+04	6.39E+04	6.16E+04	4254.73	6.90
SELENIUM	7.61E+02	0.00E+00	1.73E+01	0.00E+00	0.00E+00	1.56E+02	338.54	217.44
SILVER	0.00E+00	1.77E+01	2.57E+00	1.39E+01	6.18E+00	8.06E+00	7.50	93.08
SODIUM	6.73E+03	2.34E+03	3.01E+03	3.43E+03	4.78E+03	4.06E+03	1741.03	42.89
SULFUR	2.20E+04	2.38E+04	2.32E+04	2.62E+04	2.75E+04	2.45E+04	2276.33	9.28
TIN	2.45E+02	2.84E+02	2.67E+02	3.08E+02	2.81E+02	2.77E+02	23.20	8.38
TITANIUM	7.37E+03	6.94E+03	5.87E+03	6.94E+03	7.04E+03	6.83E+03	566.45	8.29
VANADIUM	4.62E+02	4.71E+02	3.85E+02	4.63E+02	4.39E+02	4.44E+02	35.19	7.93
ZINC	6.08E+03	6.61E+03	5.38E+03	6.58E+03	6.25E+03	6.18E+03	500.20	8.09
TOTAL:	2.55E+05	2.45E+05	2.24E+05	1.97E+05	2.20E+05	2.28E+05		

TABLE 6. COMPARISON OF METALS CONTENT FROM TEST PROGRAM SLUDGE AND TYPICAL SLUDGE (TOTAL OF DRY SOLIDS BASIS)

	METALS CONTENT OF SLUDGE FEED (PPM)	
METAL	TEST PROGRAM AVERAGE	TYPICAL CONTENT[a]
ALUMINUM	3.38E+02	1.83E+04
ANTIMONY	6.51E+01	1.00E+01
ARSENIC	1.78E+02	1.40E+01
BARIUM	2.58E+01	6.00E+02
CADMIUM	6.73E+01	1.00E+o2
CALCIUM	1.29E+04	3.62E+04
CHROMIUM	1.16E+02	1.40E+03
COBALT	1.11E+01	1.00E+01
COPPER	1.42E+03	1.30E+03
GOLD	1.04E+00	--[b]
IRON	1.79E+04	3.06E+04
LEAD	2.11E+02	1.80E+03
MAGNESIUM	4.99E+03	6.00E+03
MANGANESE	9.33E+01	1.90E+02
NICKEL	4.87E+01	--[b]
PHOSPHORUS	1.91E+04	1.56E+04
SELENIUM	4.84E+01	3.00E+00
SILVER	2.50E+00	--[b]
SODIUM	1.26E+03	4.40E+03
SULFUR	7.60E+03	--[b]
TIN	8.59E+01	2.20E+02
TITANIUM	2.11E+03	2.30E+03
VANADIUM	1.38E+02	4.00E+01
ZINC	1.92E+03	2.10E+03

[a] Reference 1.

[b] Data not provided in Reference 1.

TABLE 7. SCRUBBER OPERATING DATA
(RUNS 02-04)

Parameter	Run 02	Run 03	Run 04	Average
Pressure Drop (in H_2O)				
1. Venturi ΔP	20.4	20.1	20.1	20.2
2. Impinger ΔP	5.0	5.0	5.0	5.0
Scrubber System Gas Temperature (^oF)				
3. Inlet	834	809	835	829
4. Outlet	81	80	80	80
Scrubber System Water Flow (GPM)	807	807	807	807

Baghouse Operating Data

Mean baghouse system operating data during the baghouse test runs are summarized in Table 8. The data show that the baghouse was operated similarly during the three runs.

The inlet gas flow rate to the baghouse was held at approximately 246 acfm by adjusting a gate valve on the baghouse ID fan. The maximum percentage deviation between the mean gas flow rate for any run and the overall average gas flow rate for all runs was less than 2 percent. Within-run variations were also very low. The average air to cloth ratio of the baghouse was 4.1 acfm:ft^2 of cloth area.

The inlet gas temperature to the baghouse was controlled by removing or adding pieces of insulation to the baghouse inlet ductwork. The average inlet gas temperature for the three baghouse runs measured using metal sheath type K thermocouples was 411°F, with the mean values for individual runs ranging from 407 to 414°F. The inlet gas temperature was very stable within each run.

Some difficulty was encountered in obtaining reliable baghouse inlet temperature readings, however. Metal sheath type K thermocouples consistently read 30 to 40°F lower than bare wire type K thermocouple when used in the 3-inch diameter baghouse inlet pipe. This discrepancy was not adequately reconciled during the tests, although it was believed to be associated with the rapid build-up of particulate matter on the outside surface of the thermocouples. Both the sheath and bare metal thermocouples gave very steady temperature readings.

Baghouse outlet temperatures were also measured using the sheath type K thermocouples. The mean baghouse outlet temperatures for individual runs ranged from 347°F to 385°F. Considering the consistency of the gas inlet temperature between runs, this indicates that the heating elements on the baghouse walls may not have been working reliably. The average gas temperature drop across the baghouse was approximately 50°F.

At the beginning of the test program it was expected that the pressure drop across the baghouse could be controlled by cleaning the bags using the mechanical shaking mechanism provided in the original system design. During the scrubber test runs (i.e., runs 1-4), the baghouse system was operated to condition the bags and to develop a set of standard operating practices that were later used in the baghouse test runs. After three days of operation, it became apparent that the mechanical shaker mechanism was not adequately removing the incinerator particulate from the bag filter surface. Exceptionally high pressure drops (on the order of 15 to 20 inches of water) were measured across the bags, and little pressure drop reduction was noted after cleaning the bags using the mechanical shaker system. Visual inspection of the bags after the first three scrubber test runs revealed that they were heavily coated with incinerator particulate. Little, if any, dust was shaken off the bags by the action of the manually operated rotating arm (i.e., the mechanical shaker system). It was ultimately decided to manually clean the bags after each test run using a soft brush. This technique reduced the

TABLE 8. BAGHOUSE OPERATING DATA
(RUNS 06-08)

Parameter	Run 06	Run 07	Run 08	Average, Baghouse Tests
Pressure Drop (in. H_2O)				
Initial △P	2.6	3.7	4.4	3.6
Final △P	4.9	5.9	9.2	6.7
Mean △P	4.1	4.8	6.5	5.1
Mean Gas Temperature (^oF)				
Inlet Temperature	412	414	407	411
Outlet Temperature	385	348	347	360
Average Temperature	399	381	377	386
Mean Gas Flow				
Actual (acfm)	250	244	243	246
Dry Standard (dscfm)	97	100	98	98
Air: Cloth Ratio (acfm:ft^2)	4.2	4.1	4.1	4.1

pressure drop across the baghouse to more acceptable levels (i.e., a range of 2.6 to 9.2 in. H_2O during the baghouse test runs).

As a result of the manual method used to clean the bags, the pressure drop across the baghouse increased steadily during the course of each test run, since the bag cleaning was performed only after the run. The pressure drop increased from 2.6 to 4.9 in H_2O during Run 06; from 3.7 to 5.9 in H_2O during Run 07; and from 4.4 to 9.2 in H_2O during Run 08. The steady rise in pressure drop from Run 06 to Run 08 indicates that the bag cleaning between runs was not sufficient to return the bags to their original condition following a run. Additional study would be needed to determine if a more vigorous bag cleaning mechanism would solve this problem. It may be that the rise in pressure drop is attributable to a slow buildup of heavy organics on the bag surface. A greenish opacity plume was generally visible from the baghouse outlet stack, indicating fairly significant organic emissions. Some of these organic species were found to readily condense on surfaces (e.g., paper) held perpendicular to the gas flow stream.

After the test program was complete, two of the used filter bags were returned to the bag vendor for physical and chemical evaluation. The major conclusions reached in the evaluation are summarized below:

1. The filter bags "as received" had measured permeability of 1.3 cfm/ft^2 @ 0.5 in H_2O, which is considered low. The bag permeability increased to 3.1 cfm/ft^2 after "light brushing" and to 4.2 cfm/ft^2 after vacuuming of the outer surface.

2. The interior surface of the bags and the bag cross-sections were found to be clean, although they were discolored.

3. Scanning Electron Microscope (SEM) photographs indicated that the membrane surface of the bags was very effective at stopping dust particles from escaping.

4. The bag material was found to be somewhat embrittled after 8 days of service, although tensile tests showed no significant loss of bag material strength.

5. Dust samples taken from the bag surface were judged by the bag vendor to be high in "early volatiles" (i.e., water and/or relatively low-boiling organics).

6. Elements identified using energy dispersive spect roscopy (EDS) in dust samples taken from the bag surface included silicon, calcium, iron, phosphorus, sulfur, aluminum, potassium, calcium, titanium, silver, copper, zinc and sodium.

TOTAL PARTICULATE EMISSIONS DATA

Total particulate emission rate data and particle size distribution data were developed using the SASS train at the baghouse inlet location (Runs 02 to 04 and 06 to 08), the scrubber outlet location (Runs 02, 03, and 04) and the baghouse outlet location (Runs 06, 07, and 08). Table 9 summarizes the total particulate mass concentration and mass emission rate data developed for each test run, and Table 10 summarizes the particle size distribution data. Total particulate removal efficiencies for the scrubber and the baghouse are presented in Table 11, and particulate removal efficiencies are shown by SASS size fraction in Table 12. These data are discussed for each sampling location in the sections below.

Baghouse Inlet Location

SASS train sampling was performed at the baghouse inlet location (i.e., the uncontrolled incinerator slipstream) during each of the test runs. Particulate concentration and particle size distribution data measured at this location should also be applicable to the incinerator outlet location since the slipstream was taken isokinetically.

The data in Table 9 show that the total particulate concentration at the baghouse inlet location was fairly consistent between test runs when compared on an as-measured O_2 basis. The uncontrolled total particulate emissions concentration at the baghouse inlet averaged 0.31 g/dscm on an as-measured O_2 basis during the scrubber test runs and 0.36 g/dscm on an as-measured O_2 basis during baghouse test runs. The maximum deviation between the concentration for any test run and the average value for all test runs was approximately 15 percent. The particulate concentration data show less consistency when corrected to 12% O_2. For example, the corrected uncontrolled total particulate emissions concentration at the baghouse inlet location averaged 0.32 g/dscm @ 12% O_2 during the scrubber test runs and 0.49 g/dscm @ 12% O_2 during the baghouse test runs. The oxygen correction was performed using Method 3 stationary gas sampling data.

Two factors that may contribute to the increased variability in the corrected particulate concentration data are: (i) errors associated with the oxygen concentration measurements using the bag sample/gas chromatograph technique; and (ii) the time variability of the excess oxygen concentration in the incinerator offgas. The stationary gas results are based on 2 30- minute integrated grab samples taken during the SASS sampling period. These potential uncertainties are magnified when the concentration data are corrected to a reference oxygen level (e.g., 12% O_2) because of the sensitivity of the correction factor to changes in the measured oxygen level.

Mass emission rates for the control device inlet streams are also shown in Table 9. The average uncontrolled mass emission rate at the scrubber inlet was 1.6 kg/hr during Runs 02-04. This value was calculated from the uncontrolled average mass emission concentration measured at the scrubber inlet during Runs 02-04 and the calculated gas flow rate at the scrubber inlet location. The average mass emission rate at the scrubber outlet as 0.089 kg/hr during Runs 06-08. This value was calculated from measured average mass emission concentrations and measured average gas flow rates during Runs 06-08.

TABLE 9. TOTAL PARTICULATE CONCENTRATIONS AND MASS EMISSION RATES

Sampling Location	Total Particulate Emissions: Concentration, g/dscm, As Measured	Total Particulate Emissions: Concentration, g/dscm, At 12% O_2	Total Particulate Emissions: Rate kg/hr
Scrubber Tests			
Inlet			
Run 02	0.30	0.28	1.35
Run 03	0.35	0.35	1.76
Run 04	0.29	0.32	1.73
Average	0.31	0.32	1.61
Outlet			
Run 02	0.0080	0.022	0.109
Run 03	0.0053	0.015	0.074
Run 04	0.0060	0.016	0.084
Average	0.0065	0.018	0.089
Baghouse Tests			
Inlet			
Run 06	0.33	0.42	0.054
Run 07	0.37	0.59	0.063
Run 08	0.38	0.47	0.064
Average	0.36	0.49	0.060
Outlet			
Run 06	0.0014	0.0019	0.00029
Run 07	0.0016	0.0023	0.00036
Run 08	0.0047	0.0072	0.0010
Average	0.0026	0.0038	0.00056

TABLE 10. TOTAL PARTICULATE CONCENTRATIONS BY SASS SIZE FRACTION

	Total Particulate Concentration Corrected to 12% O_2 (g/dscm)				
Sampling Location	Probe Rinse/ 10 Micron Cyclone	3 Micron Cyclone	1 Micron Cyclone	Filter	Total
Uncontrolled Emissions					
Run 02	0.18	0.068	0.0032	0.029	0.28
Run 03	0.22	0.086	0.0149	0.035	0.35
Run 04	0.20	0.079	0.0047	0.034	0.32
Run 06	0.25	0.126	0.0136	0.031	0.42
Run 07	0.33	0.189	0.0283	0.040	0.58
Run 08	0.27	0.137	0.0245	0.041	0.47
Average	0.24	0.114	0.0145	0.035	0.40
Scrubber Emissions					
Run 02	0.0093	0.0	0.0	0.013	0.022
Run 03	0.0024	0.0	0.0	0.013	0.015
Run 04	0.0014	0.0	0.0	0.014	0.016
Average	0.0044	0.0	0.0	0.013	0.018
Baghouse Emissions					
Run 06	0.0013	0.0	0.0	0.0006	0.0019
Run 07	0.0019	0.0	0.0	0.0004	0.0023
Run 08	0.0070	0.0	0.0	0.0002	0.0072
Average	0.0034	0.0	0.0	0.0004	0.0038

TABLE 11. TOTAL PARTICULATE REMOVAL EFFICIENCY

Baghouse		Scrubber	
Run 6	99.4660	Run 2	91.9460
Run 7	99.4300	Run 3	95.7600
Run 8	98.4180	Run 4	95.1390
Average	99.1050	Average	94.2820

TABLE 12. PARTICULATE REMOVAL EFFICIENCY BY SASS SIZE FRACTION

	Probe + 10 µm	3 µm Cyclone	1 µm Cyclone	Filter Catch	TOTAL
Baghouse					
Run 6	99.3760	100.0000	100.0000	97.7570	99.4660
Run 7	99.1470	100.0000	100.0000	98.7090	99.4300
Run 8	97.3230	100.0000	100.0000	99.4260	98.4180
Average	98.6150	100.0000	100.0000	98.6310	99.1050
Scrubber					
Run 2	94.7800	100.0000	100.0000	54.6930	91.9460
Run 3	98.9140	100.0000	100.0000	64.2670	95.7600
Run 4	99.3110	100.0000	100.0000	58.3740	95.1460
Average	97.6680	100.0000	100.0000	59.1110	94.2820

The particle size distribution data shown in Table 10 for the uncontrolled incinerator emissions are summarized graphically in Figures 9 and 10. These data show that particulate matter was captured in all SASS train size fractions for each test run. The particle size distributions were similar for the various runs. The probe rinse and 10 micron cyclone catch accounted for approximately 60 percent of the total catch; the 3 micron cyclone, 28 percent; the 1 micron cyclone, 3 to 4 percent; and the filter catch, 8 to 9 percent.

Scrubber Outlet Location

SASS train sampling was performed at the scrubber exhaust stack location during test runs 02, 03, and 04 (i.e., scrubber test runs). The emissions data in Table 9 show that the total particulate concentration at the scrubber exhaust stack location was fairly consistent between runs. The controlled total particulate emissions concentration at the scrubber outlet averaged 0.0065 g/dscm on an as-measured O_2 basis and 0.018 g/dscm when corrected to 12% O_2. The maximum percentage deviation of the scrubber outlet concentration for any individual scrubber test run from the mean for all scrubber test runs was approximately 25 percent. The total particulate mass emission rate for the scrubber averaged 0.089 kg/hr for the three scrubber test runs. As shown in Table 11, the average total particulate removal efficiency for the scrubber system was 94.3 percent, with a range for individual runs of 91.9 to 95.8 percent.

The SASS train particle size distribution data in Table 10 for the scrubber particulate emissions are shown graphically in Figure 11. The data show that particulate emissions from the scrubber were captured only in the probe rinse/10 micron cyclone fraction and the filter fraction of SASS train catch, with no particulate matter captured in the 3 micron and 1 micron cyclones. The filter catch was the largest contributor to the total particulate mass for each test run. The average percentages of the total particulate emissions contributed by the probe/rinse 10 micron cyclone catch and filter catch were 25 percent and 75 percent, respectively. Run 02 had a considerably higher percentage of the total particulate emission contributed from the probe rinse/10 micron cyclone catch (42 percent) than Runs 03 and 04 (12 percent). This anomaly could not be explained by a consideration of potential sampling uncertainties.

Particulate removal efficiencies for the scrubber system are shown by SASS size fraction in Table 12. The removal efficiency for the probe rinse/10 micron catch averaged 97.7 percent for the test runs, with a range for individual runs of 94.8 percent to 99.3 percent. Removal efficiencies for the 3 micron and 1 micron cyclone catches were 100 percent for all test runs, since no particulate was captured in these cyclones at the scrubber exhaust stack. The removal efficiency for particulate matter in the SASS train filter catch was low for all three scrubber test runs, with an average of 59.1 percent. The range for individual runs was 54.7 percent to 64.3 percent.

Figure 12 gives a graphic representation of the average scrubber system particulate removal efficiency data. The parameter (1-scrubber efficiency) is

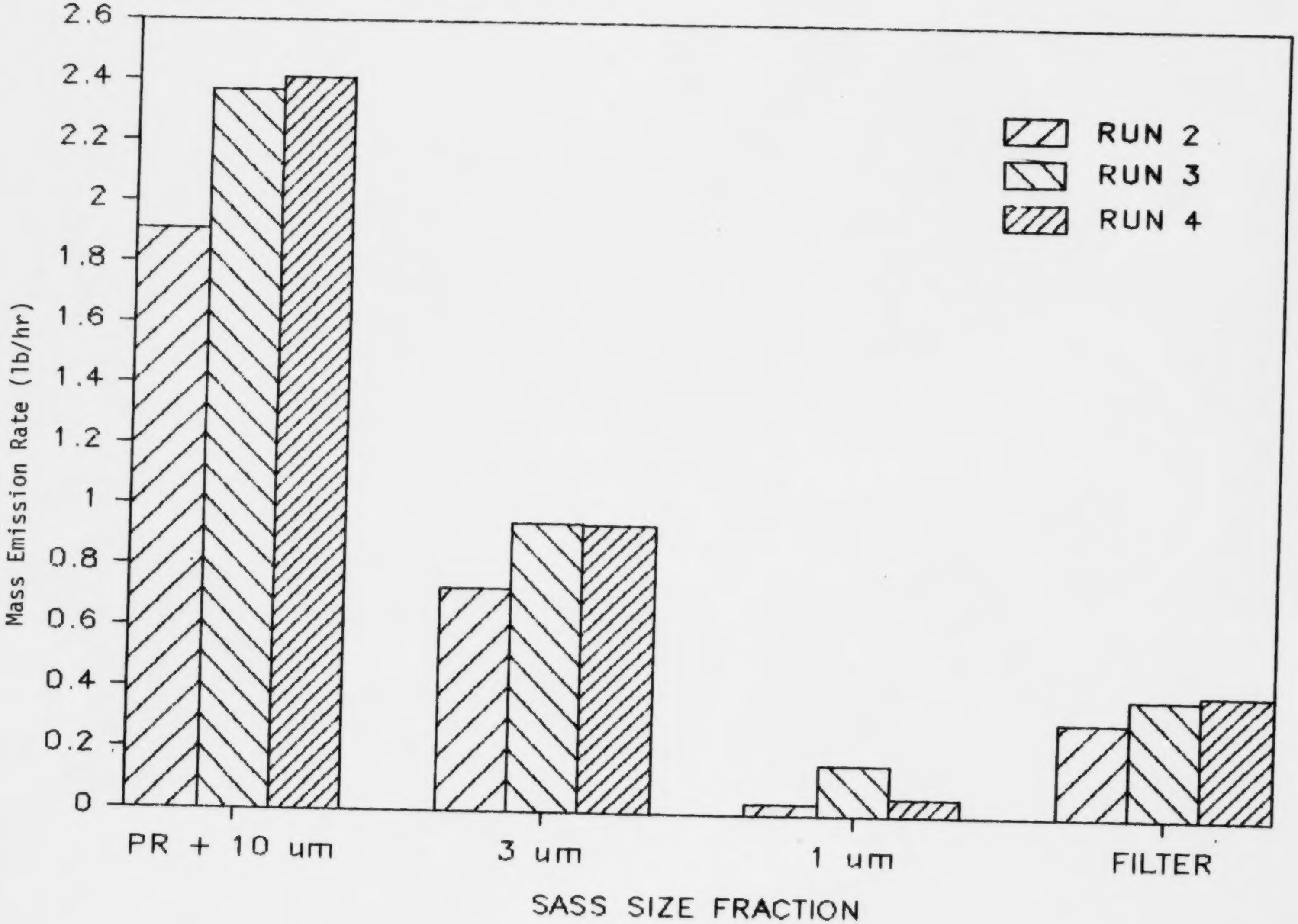

Figure 9. Particle Size Distribution of the Uncontrolled Particulate Emissions from the Incinerator (Scrubber Test Runs)

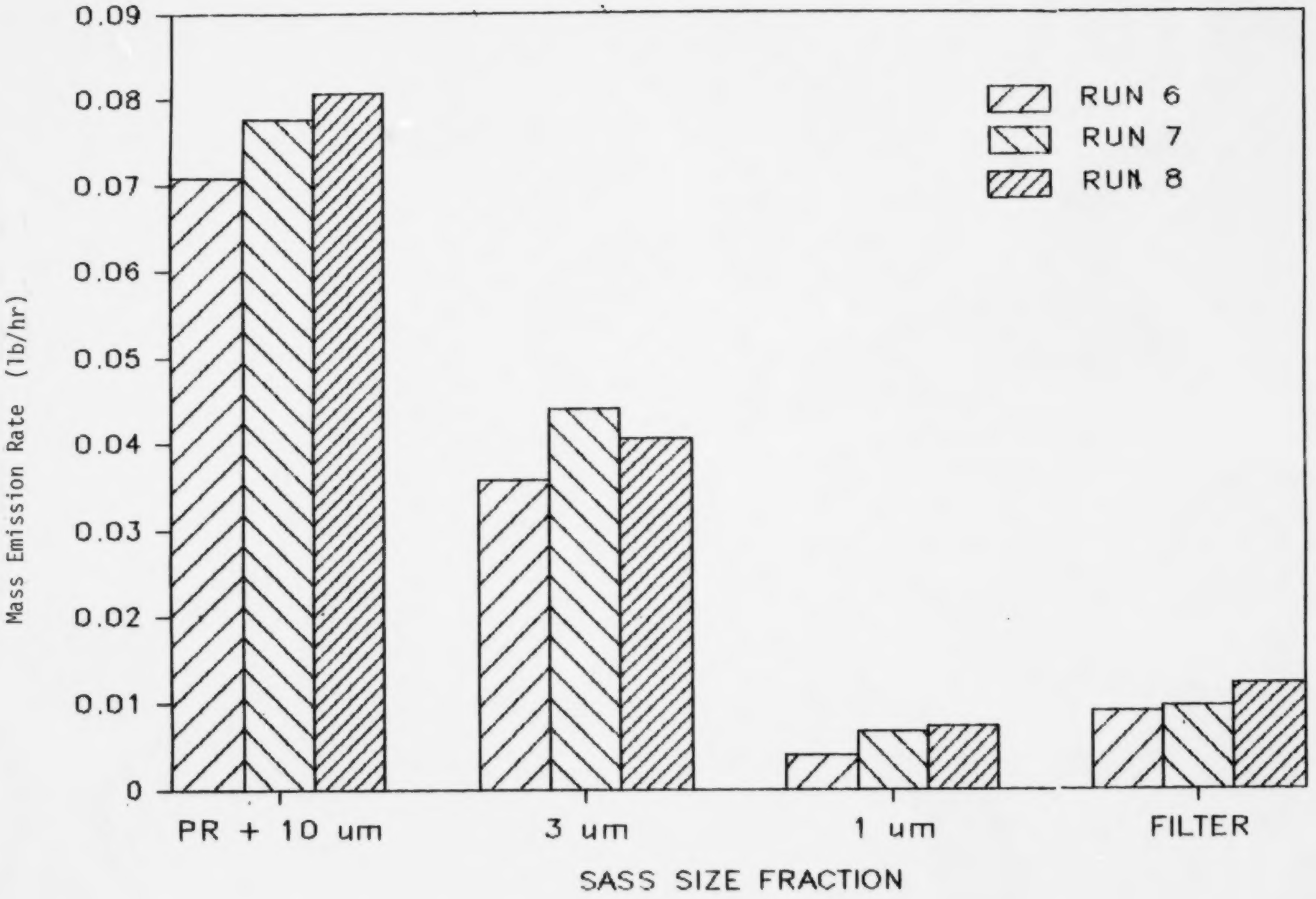

Figure 10. Particle Size Distribution of the Uncontrolled Particulate Emissions from the Incinerator (Baghouse Test Runs)

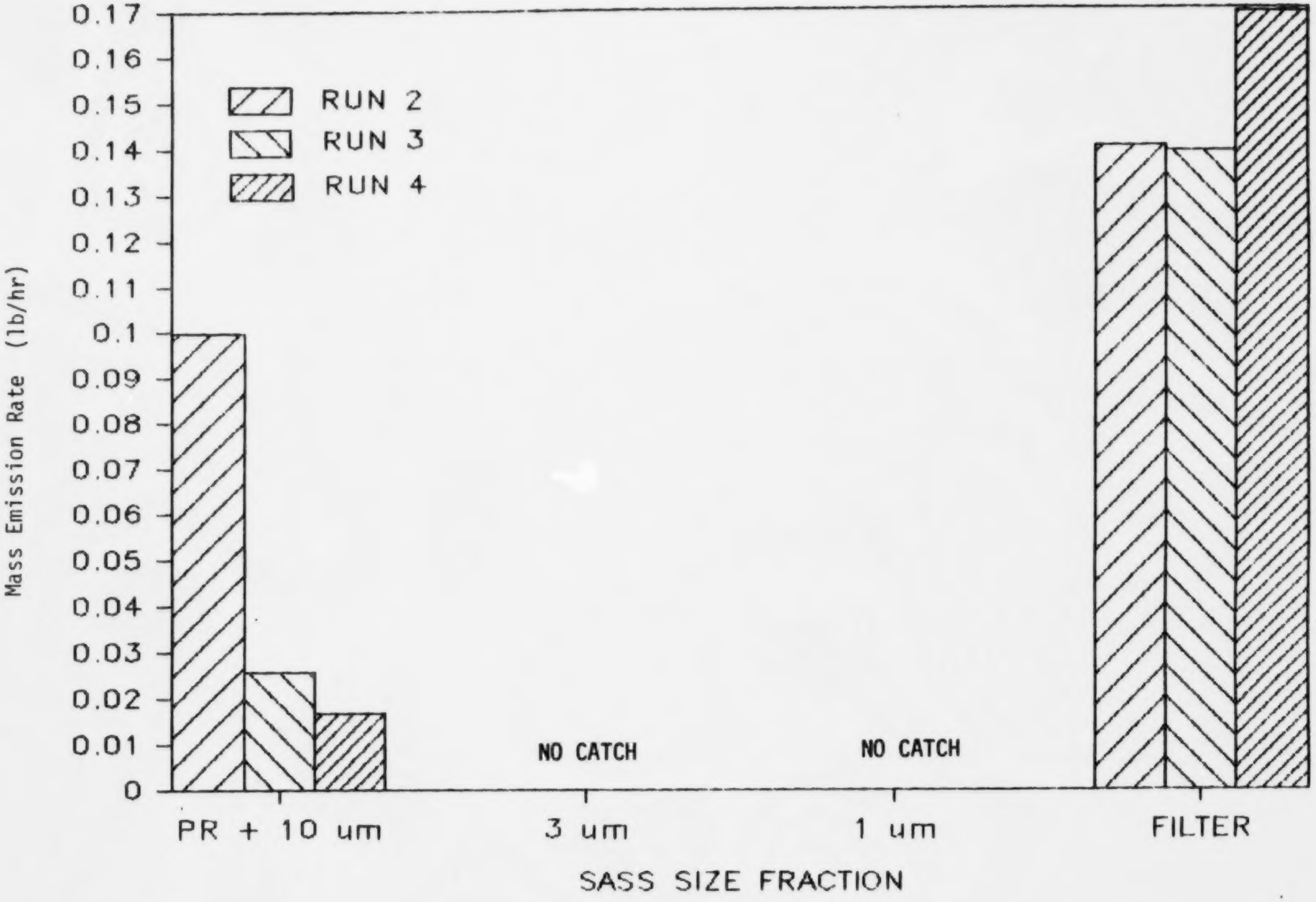

Figure 11. Particle Size Distribution of Particulate Emissions from the Scrubber

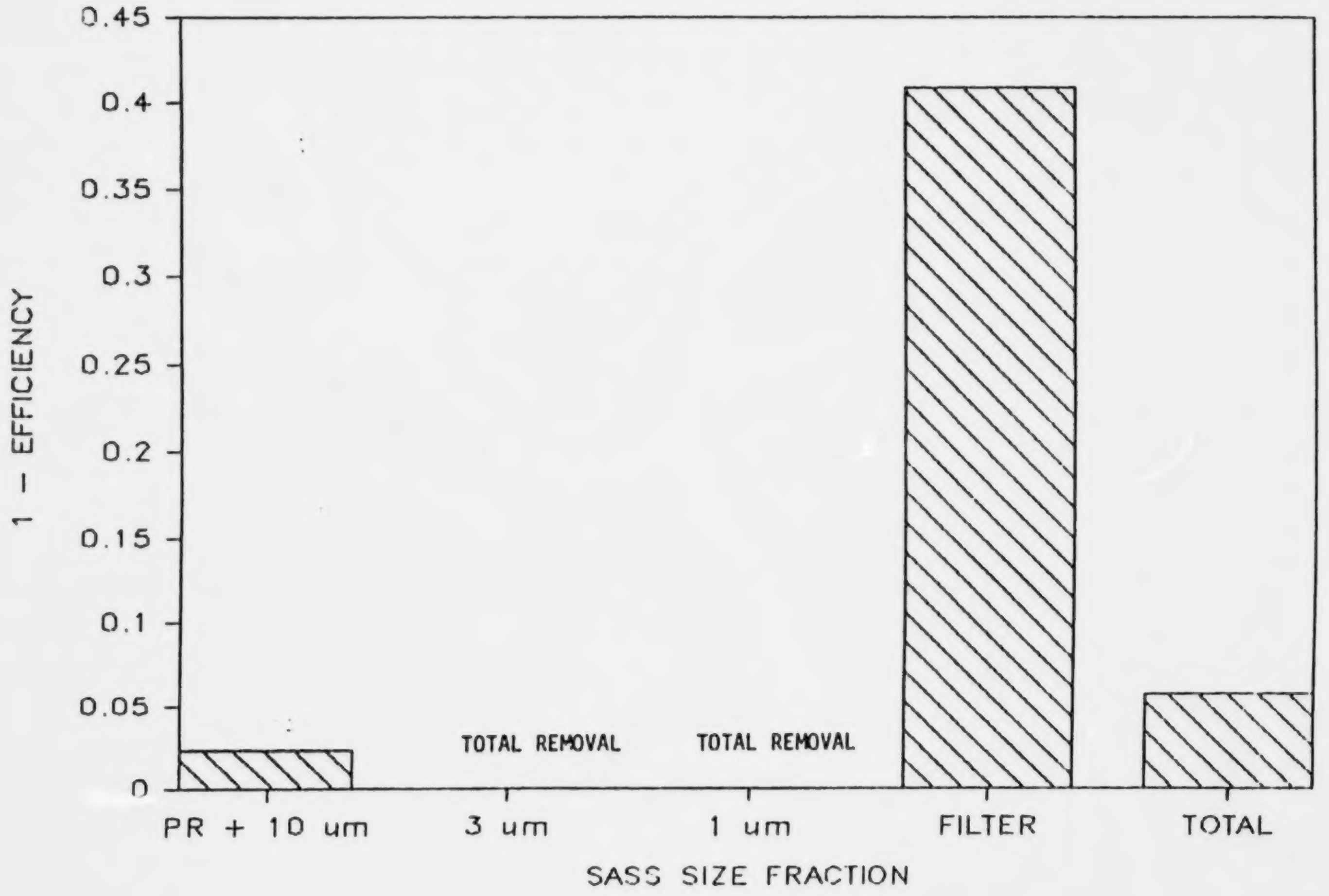

Figure 12. Particulate Removal Efficiency by SASS Train Size Fraction for the Scrubber

plotted in bar graph form for each SASS train size fraction. This parameter is equivalent to the ratio of the scrubber inlet mass emissions rate divided by the scrubber outlet mass emission rate (i.e., "relative emissions"). The higher the value of the 1-efficiency parameter for any SASS size fraction, the lower the control efficiency for that fraction. Figure 12 shows that the scrubber system was effective for controlling emissions of large diameter particulate matter (i.e., >1 micron aerodynamic diameter), but ineffective for controlling emissions of fine particulate matter (i.e., SASS train filter catch).

Baghouse Outlet Location

SASS train sampling was performed at the baghouse outlet location during test runs 06, 07, and 08 (i.e., baghouse test runs). The emissions data in Table 9 show that the total particulate concentration at the baghouse outlet averaged 0.0026 g/dscm on an as-measured O_2 basis and 0.0038 g/dscm when corrected to 12 percent O_2. Run 08 had significantly higher total particulate emissions (0.0047 g/dscm) than Runs 06 and 07 (0.0015 g/dscm), but no explanation was apparent for this difference. The total particulate mass emission rate for the baghouse outlet location averaged 0.00056 kg/hr, with Run 08 again being significantly higher than Runs 06 and 07. As shown in Table 9, the average total particulate removal efficiency for the baghouse was 99.1 percent, with a range for individual runs of 98.4 to 99.5 percent.

The baghouse emission particle size distribution data listed in Table 10 are shown graphically in Figure 13. The data show that particulate emissions from the baghouse were captured only in the probe rinse/10 micron cyclone fraction and the filter of the SASS train, with no particulate matter captured in the 3 micron and 1 micron cyclones. The probe rinse/10 micron cyclone catch was the largest contributor to the total particulate mass for all test runs. The average percentage contribution of the probe rinse/10 micron fraction to the total SASS train particulate catch was 89 percent, with a range of 69 to 97 percent for individual runs. The average percentage contribution of the filter catch to the total SASS train particulate catch was 11 percent, with a range of 3 to 31 percent for individual runs. The large probe rinse/10 micron fraction emission rate for Run 08 was the reason for the high total particulate emission rate noted above for Run 08.

Particulate removal efficiencies for the baghouse are shown for each SASS size fraction in Table 12. The average removal efficiency for the probe rinse/10 micron catch was 98.6 percent, with a range for individual runs of 97.3 to 99.4 percent. Removal efficiencies for the 3 micron and 1 micron SASS cyclone catches were 100 percent for all test runs, since no particulate matter was captured in these cyclones at the baghouse outlet. The average efficiency for particulate matter in the filter catch was 98.6 percent, with a range for individual runs of 97.8 to 99.4 percent.

Figure 14 shows a bar graph of the parameter (1-baghouse efficiency) for each SASS train size fraction. The figure shows that the baghouse was effective for controlling emissions from all SASS train size fractions.

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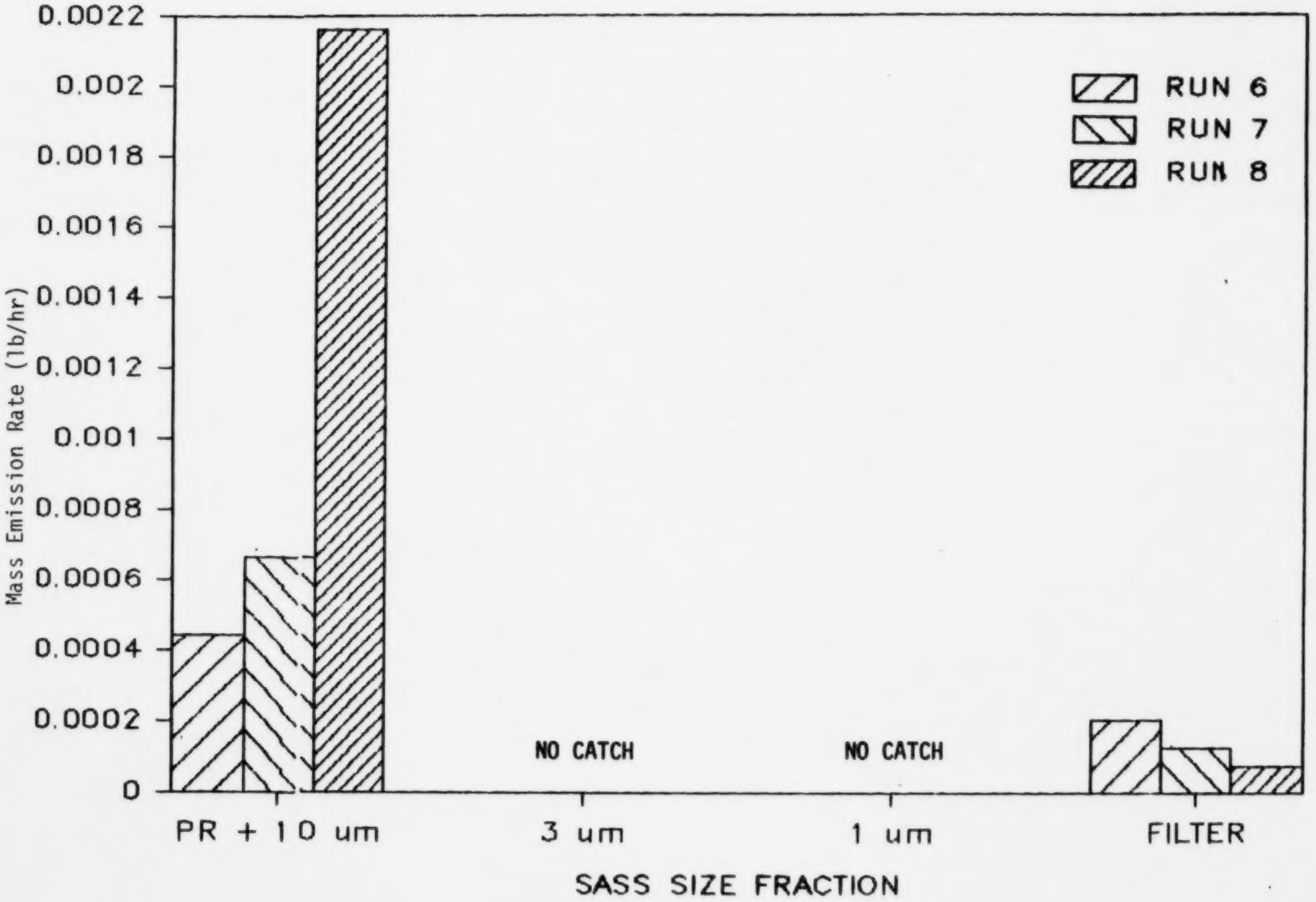

Figure 13. Particle Size Distribution of Particulate Emissions from the Baghouse

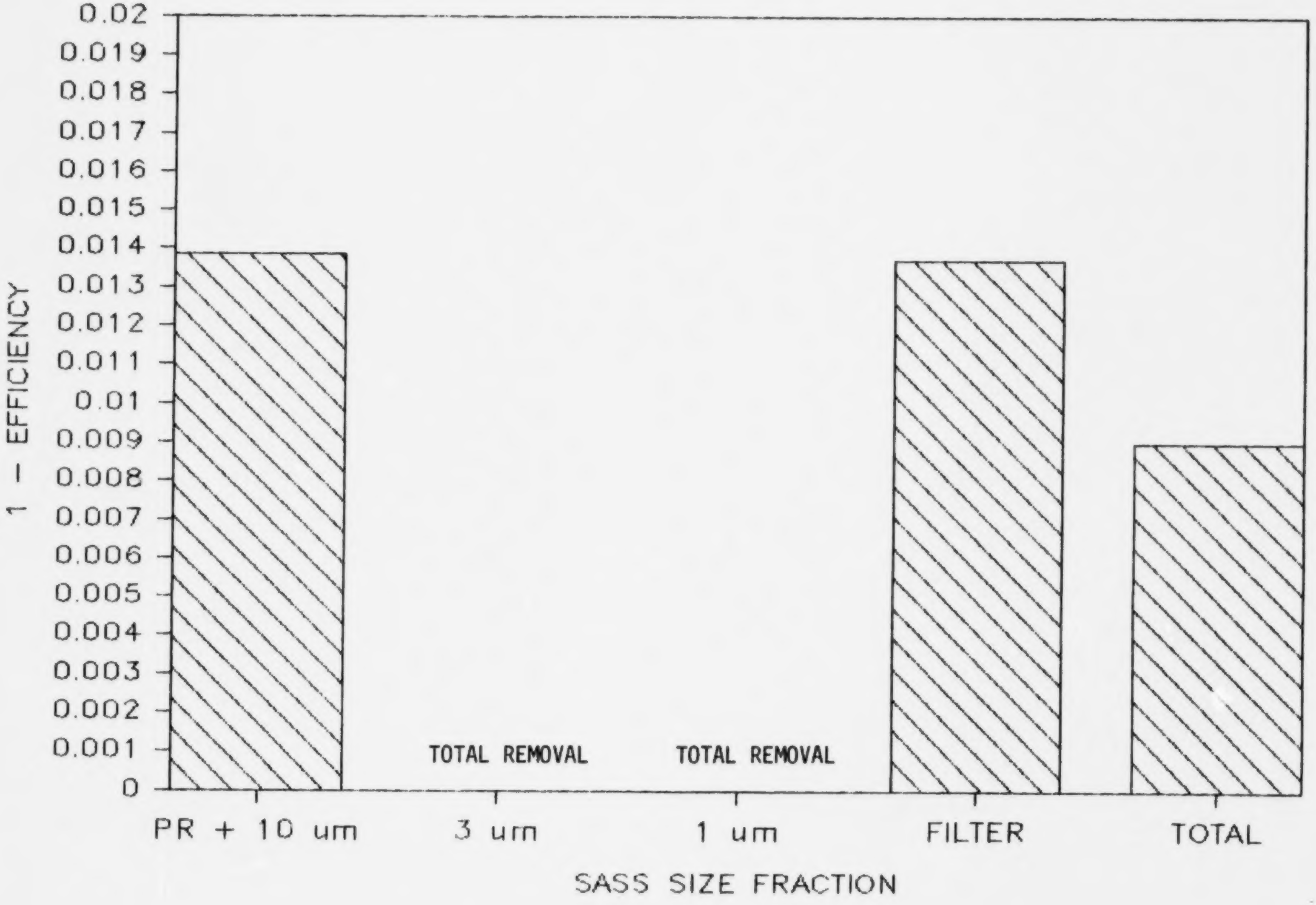

Figure 14. Particulate Removal Efficiency by SASS Train Size Fraction for the Baghouse

TRACE METALS EMISSIONS DATA

Trace metals emissions data developed by the ICAP analysis of the SASS train particulate fractions are presented in this section. Uncontrolled trace metals emissions data for the incinerator (as measured at the baghouse inlet location) are presented below. Trace metals flue gas concentration, enrichment ratios, and particle size distribution data are used to characterize uncontrolled trace metals emissions from the incinerator.

Controlled trace metal emissions from the scrubber system and the mobile baghouse are presented in this Section. Total trace metals emission concentrations, enrichment ratios, particle size distribution data, and removal efficiency results are used to characterize controlled trace metal emissions from the scrubber system and the baghouse.

Uncontrolled Trace Metals Emissions (Baghouse Inlet)

Total Trace Metals Emissions. ICAP analyses of the SASS train particulate matter and impinger samples from the baghouse inlet location are contained in Appendix A for all test runs. The corresponding total uncontrolled trace metals emissions concentrations (corrected to 12% O_2) are presented in Tables 13 and 14 for the scrubber and baghouse test runs, respectively. The concentrations in the tables include the contributions of the impinger catch except for chromium, nickel, and iron. Contamination of the impinger catch by stainless steel was suspected for these metals, as discussed in Section 5. The data show that the uncontrolled incinerator emissions of the various metals are fairly consistent between test runs.

For several of the metals, high filter blank results may have affected the concentrations measured, as discussed in Section 5. For the scrubber inlet runs, the metals which may have uncertain results are sodium, aluminum, lead, chromium, and selenium. For the baghouse inlet runs, the metals are sodium, aluminum, and nickel.

Trace Metals Enrichment Ratios in the Uncontrolled Emissions. The enrichment ratio for a given metal "i" is defined as the concentration of metal i in the particulate emissions (ug/g) divided by the concentration of metal i in the dry, volatiles free sludge. The impinger contributions to the metal emissions were not included in the enrichment ratio calculations. Tables 15 and 16 summarize the average enrichment ratios of the uncontrolled incinerator emissions measured at the baghouse inlet location during the scrubber and baghouse test runs. Because of high filter blank results, enrichment ratios for some of the metals are uncertain, as discussed in Section 5. For the scrubber inlet runs, the metals with uncertain results are sodium, aluminum, lead, chromium, and selenium. For the baghouse inlet runs, the metals are sodium, aluminum, and nickel.

The average enrichment ratios range from a low of about 1 for phosphorus and titanium to a high of 25 for cadmium. The species with the lowest enrichment ratios in the uncontrolled emissions were titanium, phosphorus, copper, calcium, iron, and zinc. These species all had average

TABLE 13. UNCONTROLLED TRACE METAL EMISSIONS FROM THE INCINERATOR (SCRUBBER TEST RUNS)

TOTAL TRACE METALS EMISSIONS (g/dscm)
CORRECTED TO 12 % OXYGEN

	SCRUBBER INLET				
METAL	RUN 2	RUN 3	RUN 4	MEAN	SD
SULFUR	1.23E-01	7.28E-02	1.22E-01	1.06E-01	2.88E-02
IRON[a]	1.92E-02	2.33E-02	1.85E-02	2.03E-02	2.59E-02
PHOSPHORUS	1.72E-02	2.20E-02	2.04E-02	1.99E-02	2.49E-03
CALCIUM	1.91E-02	1.88E-02	1.35E-02	1.71E-02	3.15E-03
MAGNESIUM	6.79E-03	7.54E-03	5.76E-03	6.70E-03	8.94E-04
ZINC	2.29E-03	2.94E-03	2.30E-03	2.51E-03	3.71E-04
SODIUM[b]	2.75E-03	2.05E-03	1.54E-03	2.11E-03	6.06E-04
TITANIUM	1.89E-03	2.28E-03	2.11E-03	2.09E-03	2.00E-04
CADMIUM	1.80E-03	2.10E-03	1.82E-03	1.90E-03	1.71E-04
ALUMINUM[b]	1.85E-03	1.10E-03	2.74E-03	1.90E-03	8.17E-04
COPPER	1.52E-03	1.88E-03	1.67E-03	1.69E-03	1.77E-04
LEAD[b]	1.34E-03	1.35E-03	1.23E-03	1.31E-03	6.59E-05
VANADIUM	4.62E-04	4.61E-04	4.46E-04	4.56E-04	9.31E-06
TIN	4.07E-04	3.91E-04	4.45E-04	4.14E-04	2.80E-05
MANGANESE	6.36E-04	2.02E-04	3.28E-04	3.89E-04	2.23E-04
ARSENIC	2.71E-04	3.06E-04	2.63E-04	2.80E-04	2.27E-05
CHROMIUM[a,b]	1.22E-04	1.63E-04	1.92E-04	1.59E-04	3.52E-05
NICKEL[a]	1.16E-04	1.24E-04	1.64E-04	1.35E-04	2.57E-05
ANTIMONY	7.75E-05	1.02E-04	8.39E-05	8.77E-05	1.26E-05
BARIUM	1.07E-04	6.22E-05	7.44E-05	8.13E-05	2.33E-05
COBALT	9.56E-05	3.11E-05	6.63E-05	6.44E-05	3.23E-05
SILVER	7.23E-05	1.93E-05	1.35E-05	3.51E-05	3.24E-05
GOLD	4.64E-06	2.90E-06	3.90E-06	3.81E-06	8.76E-07
SELENIUM[b]	0.00E+00	3.02E-06	0.00E+00	1.01E-06	1.75E-06

[a] Results do not include impinger catch because of suspected stainless steel contamination.

[b] Concentration for one or more runs may have been affected by high filter blank result.

TABLE 14. UNCONTROLLED TRACE METAL EMISSIONS FROM THE INCINERATOR (BAGHOUSE TEST RUNS)

TOTAL TRACE METALS EMISSIONS (g/dscm)
CORRECTED TO 12 % OXYGEN

	BAGHOUSE INLET				
METAL	RUN 6	RUN 7	RUN 8	MEAN	SD
SULFUR	8.67E-02	9.22E-02	1.44E-01	1.08E-01	3.17E-02
IRON[a]	2.47E-02	3.50E-02	3.32E-02	3.10E-02	5.50E-03
PHOSPHORUS	2.52E-02	1.89E-02	3.24E-02	2.55E-02	6.73E-03
CALCIUM	2.04E-02	2.48E-02	3.07E-02	2.53E-02	5.15E-03
MAGNESIUM	8.96E-03	9.20E-03	1.02E-02	9.46E-03	6.67E-04
ZINC	3.11E-03	4.75E-03	3.68E-03	3.85E-03	8.33E-04
TITANIUM	2.76E-03	4.36E-03	3.43E-03	3.52E-03	8.02E-04
COPPER	2.25E-03	3.25E-03	2.58E-03	2.69E-03	5.09E-04
SODIUM[b]	1.61E-03	2.63E-03	3.70E-03	2.65E-03	1.05E-03
CADMIUM	2.29E-03	3.18E-03	2.11E-03	2.53E-03	5.76E-04
LEAD	1.98E-03	2.48E-03	1.53E-03	1.99E-03	4.77E-04
ALUMINUM[b]	1.28E-03	1.35E-03	1.67E-03	1.44E-03	2.08E-04
TIN	6.56E-04	7.94E-04	4.88E-04	6.46E-04	1.53E-04
VANADIUM	1.01E-03	5.08E-04	3.49E-04	6.21E-04	3.43E-04
ARSENIC	3.29E-04	4.76E-04	3.96E-04	4.00E-04	7.37E-05
MANGANESE	1.76E-04	3.86E-04	1.90E-04	2.51E-04	1.17E-04
CHROMIUM[a]	1.64E-04	3.39E-04	2.06E-04	2.36E-04	9.14E-05
NICKEL[a,b]	1.28E-04	2.16E-04	1.36E-04	1.60E-04	4.87E-05
COBALT	3.02E-05	5.69E-05	2.89E-04	1.25E-04	1.43E-04
ANTIMONY	1.01E-04	1.53E-04	9.73E-05	1.17E-04	3.10E-05
BARIUM	4.98E-05	1.39E-04	1.33E-04	1.07E-04	4.97E-05
SELENIUM	4.06E-05	2.22E-04	6.61E-06	8.98E-05	1.16E-04
SILVER	2.60E-05	1.50E-05	4.64E-05	2.91E-05	1.59E-05
GOLD	4.12E-06	5.19E-06	2.84E-06	4.05E-06	1.18E-06

[a] Results do not include impinger catch because of suspected stainless steel contamination.

[b] Concentration for one or more runs may have been affected by high filter blank result.

TABLE 15. PARTICULATE MATTER ENRICHMENT RATIOS FOR THE UNCONTROLLED INCINERATOR EMISSIONS (Scrubber Test Runs)

	ENRICHMENT RATIOS [a]		
	SCRUBBER INLET		
	RUN 3	RUN 4	AVG
ALUMINUM[b]	5.31	14.37	9.84
ANTIMONY	1.50	1.21	1.35
ARSENIC	1.44	1.48	1.46
BARIUM	3.01	2.56	2.79
CADMIUM	27.40	23.80	25.60
CALCIUM	0.97	0.78	0.87
CHROMIUM	1.34	1.55	1.44
COBALT	1.28	1.20	1.24
COPPER	1.13	1.14	1.13
GOLD	1.54	2.80	2.17
IRON	1.02	0.92	0.97
LEAD[b]	6.13	5.47	5.80
MAGNESIUM	1.13	0.86	0.99
MANGANESE	1.28	1.22	1.25
NICKEL	2.45	2.70	2.58
PHOSPHOROUS	0.94	1.05	0.99
SELENIUM[b]	0.01	ND	0.01
SILVER	ND	2.38	1.19
SODIUM[b]	0.87	2.05	1.46
SULFUR	1.28	1.22	1.25
TIN	4.54	4.90	4.72
TITANIUM	0.88	0.95	0.91
VANADIUM	2.84	2.95	2.89
ZINC	1.36	1.08	1.22

[a] Sludge feed metals data not available for Run 02.

[b] Results for one or more runs may have been affected by a high filter blank result.

TABLE 16. PARTICULATE MATTER ENRICHMENT RATIOS FOR THE UNCONTROLLED INCINERATOR EMISSIONS (Baghouse Test Runs)

	ENRICHMENT RATIOS			
	BAGHOUSE INLET			
	RUN 6	RUN 7	RUN 8	AVG
ALUMINUM[a]	4.53	0.97	3.02	2.84
ANTIMONY	1.22	1.17	0.94	1.11
ARSENIC	1.48	1.41	1.40	1.43
BARIUM	1.87	2.71	2.43	2.33
CADMIUM	27.45	22.92	22.96	24.44
CALCIUM	0.97	2.48	2.01	1.82
CHROMIUM	1.13	1.56	1.05	1.25
COBALT	1.45	1.16	1.18	1.26
COPPER	1.32	1.14	1.16	1.21
GOLD	2.74	2.52	ND	1.76
IRON	1.12	1.12	1.25	1.16
LEAD	7.87	5.46	4.64	5.99
MAGNESIUM	1.08	1.90	1.70	1.56
MANGANESE	1.43	1.27	1.21	1.30
NICKEL[a]	2.57	2.34	1.60	2.17
PHOSPHOROUS	1.08	0.50	1.05	0.88
SELENIUM	0.00	ND	ND	0.00
SILVER	24.31	1.86	15.91	14.03
SODIUM[a]	1.28	1.31	1.61	1.40
SULFUR	0.92	0.77	0.59	0.76
TIN	5.70	4.42	3.51	4.54
TITANIUM	1.13	1.08	1.03	1.08
VANADIUM	6.25	1.85	1.68	3.26
ZINC	1.39	1.24	1.24	1.29

[a] Results for one or more runs may have been affected by a high filter blank result.

enrichment ratios of 1.3 or less. The species with the highest enrichment ratios in the uncontrolled emissions included cadmium, lead, and tin. These species are generally considered volatile or semi-volatile. Each of these species had enrichment ratios of 4.5 or greater.

Distribution of Trace Metals by SASS Train Size Fraction. The distribution of trace metal emissions by SASS train size fraction of the baghouse inlet varied significantly for the 24 species analyzed. A table of fractional metals distribution data is contained in Appendix A for each test run. These data are summarized in Tables 17 and 18. The distributions for chromium, iron, and nickel do not include the impinger catch results because of suspected stainless steel contamination, as discussed in Section 5. Many species (e.g., titanium, phosphorus, copper, calcium, iron, and zinc) were distributed predominantly in the large SASS particle size fractions (i.e., the probe rinse/10 micron cyclone catch and the 3 micron cyclone catch). Typically, 40-60 weight percent of the total catch of these elements was found in the probe rinse/10 micron cyclone fraction, and 20-30 percent was found in the 3 micron cyclone catch. The 1 micron cyclone, filter, and impinger catches accounted for a total of only 10-15 percent of these metals. Thus, the particle size distributions of these elements were similar to the particle size distribution of the total particulate matter.

Other species (e.g., cadmium, nickel, tin, aluminum, lead) were distributed more evenly in the 5 SASS size fractions. Approximately 10-30 percent of the total catch of these species was found in the probe rinse/10 micron cyclone catch, and 5-25 percent was found in the 3 micron cyclone catch. Thus, the more volatile species were found to be preferentially associated with the fine particulate matter. The particle size distribution of these species do not necessarily mirror the particle size distribution of the total particulate.

Trace Metals Emissions from the Scrubber

Total Trace Metals Emissions. ICAP analyses of the SASS train particulate matter and impinger samples from the scrubber outlet location are contained in Appendix A (Runs 02-04). The corresponding total trace metals emissions concentrations (corrected to 12% O_2) are presented in Table 19. The results for chromium, iron, and nickel do not include the impinger catch because of suspected stainless steel contamination, as discussed in Section 5. In general, the scrubber emissions show more variability between runs than the corresponding uncontrolled incinerator emissions. The increased variability is most likely due to analytical uncertainties associated with the smaller sample size of the particulate matter catch at the scrubber outlet. Additional uncertainty may be due to high filter blank results for some metals, as discussed in Section 5.2. The metals include aluminum, sodium, zinc, calcium, iron, barium, arsenic, titanium, and nickel. There is also evidence of contamination with chromium of the probe + 10 μm fraction of the emissions catch at the scrubber outlet. This evidence is discussed in Section 5.

TABLE 17. AVERAGE TRACE METALS PARTICLE SIZE DISTRIBUTION IN THE UNCONTROLLED INCINERATOR EMISSIONS (SCRUBBER TEST RUNS)

	SCRUBBER INLET				
	PROBE + 10 um	3 um CYCLONE	1 um CYCLONE	FILTER CATCH	IMPINGER CATCH
ALUMINUM[a]	11.90	6.54	10.94	70.62	0.00
ANTIMONY	58.34	22.65	1.80	17.21	0.00
ARSENIC	61.20	24.03	2.65	5.20	6.92
BARIUM	19.41	9.08	4.04	67.46	0.00
CADMIUM	17.30	19.72	4.51	58.34	0.12
CALCIUM	88.00	9.37	1.09	1.47	0.06
CHROMIUM[b]	63.10	20.86	4.63	11.41	--
COBALT	12.73	5.55	0.52	2.39	78.82
COPPER	51.95	23.20	2.91	21.60	0.33
GOLD	75.63	12.53	0.00	11.84	0.00
IRON[b]	70.00	25.39	2.80	1.81	--
LEAD[a]	20.58	18.52	3.88	57.02	0.00
MAGNESIUM	66.78	29.78	1.61	1.73	0.09
MANGANESE	21.44	8.55	0.81	0.86	68.34
NICKEL[b]	40.02	22.76	4.42	32.79	--
PHOSPHORUS	65.03	27.21	2.72	2.00	3.04
SELENIUM[a]	0.00	44.36	0.00	55.64	0.00
SILVER	30.60	43.65	4.08	21.67	0.00
SODIUM[a]	61.24	14.85	1.95	21.96	0.00
SULFUR	3.84	2.64	0.35	1.99	91.18
TIN	17.63	13.05	2.80	66.52	0.00
TITANIUM	68.05	27.34	2.81	1.81	0.00
VANADIUM	31.23	21.66	3.07	44.03	0.00
ZINC	52.85	24.86	2.89	18.82	0.58

[a] Results of one or more runs may have been affected by high filter blank result.

[b] Results of impinger catch not included because of suspected stainless steel contamination.

TABLE 18. AVERAGE TRACE METALS PARTICLE SIZE DISTRIBUTION IN THE UNCONTROLLED INCINERATOR EMISSIONS (BAGHOUSE TEST RUNS)

	BAGHOUSE INLET				
	PROBE + 10 um	3 um CYCLONE	1 um CYCLONE	FILTER CATCH	IMPINGER CATCH
ALUMINUM [a]	21.30	12.59	16.87	49.24	0.00
ANTIMONY	56.65	24.92	2.67	15.76	0.00
ARSENIC	54.83	34.25	5.77	5.15	0.00
BARIUM	23.04	11.14	5.34	60.48	0.00
CADMIUM	17.89	31.75	9.45	40.48	0.44
CALCIUM	50.07	37.77	5.76	6.30	0.10
CHROMIUM [b]	54.98	33.53	5.51	5.98	--
COBALT	8.90	5.00	0.84	1.41	83.85
COPPER	45.35	34.49	6.63	13.25	0.28
GOLD	45.93	30.99	6.94	16.14	0.00
IRON [b]	56.35	36.52	5.73	1.39	--
LEAD	19.62	24.14	7.93	48.31	0.00
MAGNESIUM	52.14	40.32	5.07	2.40	0.07
MANGANESE	42.37	26.19	4.34	2.09	25.01
NICKEL [a,b]	41.05	32.15	6.58	20.22	--
PHOSPHORUS	48.39	41.83	6.45	2.04	1.28
SELENIUM	0.00	0.00	0.00	3.52	96.48
SILVER	12.84	55.05	16.79	15.32	0.00
SODIUM [a]	37.07	32.42	7.30	22.29	0.91
SULFUR	2.80	3.17	0.71	1.79	91.53
TIN	15.69	18.79	5.28	57.91	2.34
TITANIUM	58.47	34.75	4.91	1.87	0.00
VANADIUM	25.97	51.94	4.45	16.96	0.67
ZINC	47.35	34.99	6.32	11.11	0.22

a Results of one or more runs may have been affected by high filter blank result.

b Results of impinger catch not included because of suspected stainless steel contamination.

TABLE 19. CONTROLLED TRACE METALS EMISSIONS FROM THE SCRUBBER

TOTAL TRACE METALS EMISSIONS (g/dscm)
CORRECTED TO 12 % OXYGEN

	SCRUBBER OUTLET				
METAL	RUN 2	RUN 3	RUN 4	MEAN	SD
SULFUR	7.08E-03	3.21E-03	5.56E-03	5.29E-03	1.95E-03
ALUMINUM[a]	1.36E-03	2.48E-04	2.39E-03	1.33E-03	1.07E-03
SODIUM[a]	3.14E-04	1.64E-03	3.72E-04	7.76E-04	7.50E-04
ZINC[a]	6.71E-04	2.66E-04	1.85E-04	3.74E-04	2.60E-04
CADMIUM	4.92E-04	1.48E-04	3.90E-04	3.43E-04	1.77E-04
CALCIUM[a]	1.36E-04	2.50E-04	4.52E-04	2.79E-04	1.60E-04
LEAD	2.45E-04	6.41E-05	2.35E-04	1.81E-04	1.01E-04
PHOSPHORUS	2.78E-04	1.39E-04	1.11E-04	1.76E-04	8.96E-05
IRON[a,b]	2.17E-04	2.10E-04	8.08E-05	1.69E-04	7.67E-05
COPPER	1.39E-04	7.01E-05	1.30E-04	1.13E-04	3.75E-05
COBALT	2.18E-04	0.00E+00	0.00E+00	7.25E-05	1.26E-04
MAGNESIUM	1.10E-04	7.53E-05	1.63E-05	6.73E-05	4.75E-05
TIN	8.43E-05	1.76E-05	7.27E-05	5.82E-05	3.56E-05
VANADIUM	7.73E-05	2.47E-05	6.84E-05	5.68E-05	2.82E-05
CHROMIUM[b,c]	2.66E-05	4.48E-05	1.04E-06	2.41E-05	2.20E-05
SELENIUM	1.98E-05	1.39E-05	4.77E-06	1.28E-05	7.59E-06
ANTIMONY	1.51E-05	9.54E-06	9.44E-06	1.14E-05	3.24E-06
BARIUM[a]	7.87E-06	2.00E-05	5.50E-06	1.11E-05	7.77E-06
ARSENIC[a]	1.32E-05	3.76E-06	1.26E-05	9.85E-06	5.28E-06
MANGANESE	7.12E-06	1.05E-05	1.15E-05	9.69E-06	2.28E-06
TITANIUM[a]	1.26E-05	7.49E-06	8.52E-06	9.54E-06	2.71E-06
NICKEL[a,b]	1.56E-05	2.75E-06	4.53E-06	7.63E-06	6.96E-06
SILVER	6.51E-06	2.50E-06	4.86E-06	4.62E-06	2.01E-06
GOLD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[a] Concentration for one or more runs may have been affected by high filter blank result.

[b] Results do not include impinger catch because of suspected stainless steel contamination.

[c] Contamination of the probe + 10 μm catch may have occurred.

Trace Metals Enrichment Ratios in Scrubber Emissions. Table 20 summarizes the average enrichment ratios of the individual species for the scrubber emissions. The average enrichment ratios for the scrubber emissions ranged from a low of 0.1 for phosphorus and magnesium to a high of 75.3 for cadmium. The data for several metals are considered suspect (see footnotes to Table 20) because of high filter blank results and other uncertainties as discussed in Section 5 and are not discussed. These metals include aluminum, sodium, zinc, calcium, iron, barium, arsenic, titanium, nickel, and chromium. The species with the highest enrichment ratios in the scrubber emissions included the toxic species cadmium and lead. Each of these species had average enrichment ratios greater than 14. The species with the lowest enrichment ratios were phosphorus, magnesium and manganese. Each of these species had enrichment ratios of less than 1 in the scrubber emissions.

Trace Metal Removal Efficiencies for the Scrubber. Trace metal removal efficiencies for the scrubber are presented in Table 21 and summarized in Table 22. The removal efficiencies for some metals may be uncertain because of high blank results, as discussed in Section 5. Metals with affected results at either the scrubber inlet or outlet may have uncertainty in the removal efficiencies. The metals affected are sodium, aluminum, lead, chromium, selenium, zinc, calcium, iron, barium, arsenic, titanium, and nickel.

Disregarding those metals where results were uncertain, the data show that some of the species were removed more efficiently by the scrubber than was total particulate (94.3%), and some were removed less efficiently. The species with the lowest removal efficiencies were cobalt, silver, and cadmium. Each of these had removal efficiencies below 85 percent. The species with the highest removal efficiencies were sulfur, manganese, magnesium, phosphorus, and gold. Each of these species had removal efficiencies greater than 95 percent.

Distribution of Trace Metals by SASS Train Size Fraction. The distribution of trace metal emissions by SASS train size fraction at the scrubber outlet varied significantly for the 24 species analyzed. Since no particulate matter was captured in the 1 micron cyclone or the 3 micron cyclone at the scrubber outlet, the trace metals were distributed only among the probe rinse/10 micron cyclone catch, the filter catch, and the impinger catch. For chromium, iron, and nickel, the impinger catch was not included because of suspected stainless steel contamination, as discussed in Section 5. A table of fractional metals distribution data is contained in Appendix A for each test run. These data are summarized in Table 23.

Sulfur, which was found to be the most abundant species analyzed for in the scrubber emissions, was predominantly distributed in the impinger fraction of the total SASS train catch. Approximately 10 percent of the captured sulfur was found in the probe rinse/10 micron cyclone catch; 20 percent was found in the filter catch; and 70 percent was found in the impinger catch. As a whole, the trace metals (i.e., non-sulfur species) were predominantly distributed in the filter fraction of the total SASS train catch. Approximately 20 percent of the trace metals was found in the probe rinse/10

TABLE 20. PARTICULATE MATTER ENRICHMENT RATIOS FOR THE CONTROLLED SCRUBBER EMISSIONS

	SCRUBBER OUTLET		
	RUN 3	RUN 4	AVG
ALUMINUM[b]	27.99	258.08	143.04
ANTIMONY[b]	3.30	2.79	3.05
ARSENIC[b]	0.42	1.46	0.94
BARIUM[b]	22.77	3.89	13.33
CADMIUM	45.28	105.42	75.35
CALCIUM[b]	0.28	0.52	0.40
CHROMIUM[c]	8.47	0.17	4.32
COBALT	0.00	0.00	0.00
COPPER	0.59	1.69	1.14
GOLD	0.00	0.00	0.00
IRON[b]	0.21	0.08	0.15
LEAD	6.85	21.44	14.15
MAGNESIUM	0.26	0.04	0.15
MANGANESE	0.24	0.22	0.23
NICKEL[b]	1.26	1.51	1.38
PHOSPHORUS	0.14	0.12	0.13
SELENIUM	1.22	ND	1.22
SILVER	ND	17.58	17.58
SODIUM[b]	16.29	10.17	13.23
SULFUR	2.04	4.55	3.29
TIN	4.81	16.41	10.61
TITANIUM[b]	0.07	0.08	0.07
VANADIUM	3.57	9.09	6.33
ZINC[b]	2.78	1.72	2.25

[a] Sludge feed metals data not available for Run 02.

[b] Results for one or more runs may have been affected by high filter blank result.

[c] Contamination of the probe + 10 μm catch may have occurred.

TABLE 21. TRACE METALS REMOVAL EFFICIENCIES FOR THE SCRUBBER

	REMOVAL EFFICIENCY[a]			
METAL	RUN 2	RUN 3	RUN 4	AVERAGE
GOLD	100.000	100.000	100.000	100.000
TITANIUM[b]	99.331	99.672	99.632	99.545
IRON[b]	98.891	99.115	99.610	99.206
PHOSPHORUS	98.377	99.367	99.505	99.083
MAGNESIUM	98.376	99.001	99.742	99.040
CALCIUM[b]	99.889	98.671	96.955	98.505
MANGANESE	98.880	94.814	96.816	96.836
ARSENIC[b]	95.132	98.770	95.638	96.514
SULFUR	94.238	95.583	95.859	95.227
NICKEL[b]	86.798	97.818	97.521	94.046
COPPER	90.889	96.266	92.892	93.349
VANADIUM	83.276	94.654	86.016	87.982
ANTIMONY	80.517	90.622	89.741	86.960
TIN	79.267	95.491	85.124	86.627
LEAD[b]	81.737	95.241	82.597	86.525
ZINC[b]	70.696	90.946	92.673	84.772
BARIUM[b]	92.668	67.875	93.258	84.600
CHROMIUM[b,d]	78.796	73.185	99.515	83.832
CADMIUM	72.595	92.978	80.405	81.993
SILVER	91.004	87.062	67.263	81.776
SODIUM[b]	88.570	20.004	77.991	62.188
ALUMINUM[b]	26.532	77.563	20.294	41.463
COBALT[c]	--	--	--	--
SELENIUM[b,c]	--	--	--	--

[a] Removal efficiency calculated as (1-(mass rate at outlet)/(mass rate at inlet)).

[b] Results for one or more runs may have been affected by high filter blank result.

[c] Negative removal efficiencies were calculated for one or more runs.

[d] Contamination of the probe + 10 µm catch at the scrubber outlet may have occurred.

TABLE 22. SUMMARY OF TRACE METALS REMOVAL EFFICIENCIES FOR THE SCRUBBER

< 65%	65 - 85%	85 - 95%	95 - 99%	> 99%
Selenium (-)[a]	Silver (81.8)	Lead (86.5)[a]	Sulfur (95.2)	Magnesium (99.0)
Cobalt (-)	Cadmium (82.0)	Tin (86.6)	Arsenic (96.5)[a]	Phosphorus (99.1)
Aluminum (-)[a]	Chromium (83.8)[a]	Antimony (87.0)	Manganese (96.8)	Iron (99.2)[a]
Sodium (62.2)[a]	Barium (84.6)[a]	Copper (93.3)	Calcium (98.5)[a]	Titanium (99.5)[a]
	Zinc (84.8)[a]	Nickel (94.0)[a]		Gold (100.0)

[a] Removal efficiencies may be inaccurate because of experimental uncertainties (see Table 20).

TABLE 23. AVERAGE TRACE METALS PARTICLE SIZE DISTRIBUTIONS FOR THE CONTROLLED SCRUBBER EMISSIONS

	SCRUBBER OUTLET		
	PROBE + 10 um	FILTER CATCH	IMPINGER CATCH
ALUMINUM [a]	1.19	98.81	0.00
ANTIMONY	46.40	53.60	0.00
ARSENIC [a]	3.53	96.47	0.00
BARIUM [a]	5.67	94.33	0.00
CADMIUM	15.98	83.72	0.30
CALCIUM [a]	46.80	47.88	5.32
CHROMIUM [b,c]	96.68	3.32	--
COBALT	0.00	0.00	100.00
COPPER	1.18	86.92	11.90
GOLD	ND	ND	ND
IRON [a,b]	50.88	49.12	--
LEAD	1.68	98.32	0.00
MAGNESIUM	97.63	0.00	2.37
MANGANESE	19.32	8.58	72.10
NICKEL [a,b]	62.55	37.45	--
PHOSPHORUS	29.90	70.10	0.00
SELENIUM	100.00	0.00	0.00
SILVER	6.88	93.12	0.00
SODIUM [a]	8.63	89.94	1.43
SULFUR	8.69	20.87	70.45
TIN	0.20	99.80	0.00
TITANIUM [a]	16.95	83.05	0.00
VANADIUM	13.23	85.88	0.88
ZINC [a]	63.34	31.23	5.44

[a] Results of one or more runs may have been affected by high filter blank result.

[b] Results of impinger catch not included because of suspected stainless steel contamination.

[c] Contamination of the probe + 10 μm catch may have occurred.

micron cyclone catch; 70 percent was found in the filter catch; and 20 percent was found in the impinger catch.

The probe rinse/10 micron cyclone catch represented the largest fraction of the total SASS train catch for six individual species: selenium, magnesium, chromium, zinc, nickel, and iron. Other metals for which the probe rinse/10 micron cyclone catch was a significant contributor included calcium and antimony. The filter catch represented the largest fraction of the total SASS train catch for fourteen individual species. These included cadmium, lead, copper, and arsenic. The impinger catch represented the largest fraction of the total SASS train catch for three species. These were sulfur, cobalt and manganese.

Trace Metals Emissions from the Baghouse

Total Trace Metals Emissions. ICAP analyses of the SASS train particulate matter samples (i.e., the probe rinse/10 micron cyclone catch and the filter catch) and impinger samples from the baghouse outlet location are contained in Appendix A (Runs 06-08). The corresponding total trace metals emissions concentration data are presented in Table 24. These data show a similar degree of variability between runs as the scrubber emissions data in Table 19. The data for chromium, nickel, and iron in Table 24 do not include results from the impinger catch because of suspected stainless steel contamination, as discussed in Section 6. For several metals (aluminum, iron, magnesium, cadmium, sodium, titanium, lead, barium, arsenic, copper, and gold), the results are uncertain because of high filter blank results, as discussed in Section 6. There is also evidence of contamination with chromium of the probe + 10 μ m fraction of the emissions catch at the baghouse outlet. This evidence is discussed in Section 6.

Trace Metals Enrichment Ratios in the Baghouse Emissions. Table 25 summarizes the average enrichment ratios of the individual species for the baghouse emissions. The average enrichment ratios for the baghouse emissions ranged from a low of 0.45 for copper to a high of 47.1 for cadmium. The data for several metals are considered suspect because of the high filter blank results as discussed in Section 6. The metals affected include aluminum, iron, magnesium, cadmium, sodium, titanium, lead, barium, arsenic, copper gold, and chromium.

Trace Metal Removal Efficiencies for the Baghouse. Trace metal removal efficiencies for the baghouse are presented in Table 26 and summarized in Table 27. The removal efficiencies for some metals may be uncertain because of high filter blank results as discussed in Section 6. Metals with affected results at either the baghouse inlet or outlet may have uncertainty in the removal efficiencies. The metals affected are sodium, aluminum, nickel, iron, magnesium, cadmium, titanium, lead, barium, arsenic, copper, gold, and chromium.

The data show that 18 of the 24 species analyzed were removed less efficiently than the total particulate (99.1% removal). The six species with higher removal efficiencies than the total particulate were calcium, iron,

TABLE 24. CONTROLLED TRACE METALS EMISSIONS FROM THE BAGHOUSE

TOTAL TRACE METALS EMISSIONS (g/dscm)
CORRECTED TO 12 % OXYGEN

	BAGHOUSE OUTLET				
METAL	RUN 6	RUN 7	RUN 8	MEAN	SD
SULFUR	9.99E-02	9.71E-02	1.80E-01	1.26E-01	4.73E-02
ALUMINUM[a]	1.47E-03	1.47E-03	1.13E-03	1.36E-03	1.96E-04
PHOSPHORUS	4.74E-04	2.88E-04	5.29E-04	4.30E-04	1.26E-04
SELENIUM	1.08E-05	4.23E-04	3.19E-04	2.51E-04	2.14E-04
IRON[a,b]	2.06E-04	2.92E-04	8.30E-05	1.94E-04	1.05E-04
CALCIUM	1.89E-04	2.29E-04	6.40E-05	1.60E-04	8.58E-05
ZINC	5.01E-05	1.41E-04	6.69E-05	8.61E-05	4.86E-05
MAGNESIUM[a]	8.42E-05	6.28E-05	2.32E-05	5.67E-05	3.10E-05
CHROMIUM[b,c]	3.36E-05	5.58E-05	5.03E-06	3.15E-05	2.55E-05
TIN	3.84E-05	4.58E-05	9.59E-06	3.12E-05	1.91E-05
CADMIUM[a]	2.87E-05	3.93E-05	2.35E-05	3.05E-05	8.05E-06
SODIUM[a]	3.39E-05	1.42E-05	1.08E-05	1.96E-05	1.25E-05
COBALT	3.44E-05	5.31E-06	0.00E+00	1.32E-05	1.85E-05
TITANIUM[a]	1.53E-05	9.91E-06	1.18E-05	1.23E-05	2.71E-06
NICKEL[b]	6.41E-06	2.70E-05	7.96E-07	1.14E-05	1.38E-05
LEAD[a]	1.78E-05	7.37E-06	5.51E-06	1.02E-05	6.60E-06
MANGANESE	7.78E-06	1.24E-05	7.36E-06	9.17E-06	2.77E-06
BARIUM[a]	4.80E-06	5.69E-06	1.50E-05	8.48E-06	5.62E-06
ANTIMONY	1.11E-06	5.88E-06	1.59E-05	7.63E-06	7.55E-06
ARSENIC[a]	6.70E-06	6.66E-06	5.17E-06	6.17E-06	8.71E-07
COPPER[a]	7.53E-06	3.71E-06	1.01E-06	4.08E-06	3.27E-06
VANADIUM	3.42E-06	6.50E-06	2.17E-06	4.03E-06	2.23E-06
SILVER	1.60E-06	9.86E-07	1.88E-07	9.26E-07	7.10E-07
GOLD[a]	0.00E+00	0.00E+00	2.24E-07	7.47E-08	1.29E-07

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[a] Concentration for one or more runs may have been affected by high filter blank result.

[b] Results do not include impinger catch because of suspected stainless steel contamination.

[c] Contamination of the probe + 10 µm catch may have occurred.

TABLE 25. PARTICULATE MATTER ENRICHMENT RATIOS FOR THE CONTROLLED BAGHOUSE EMISSIONS

	BAGHOUSE OUTLET			
	RUN 6	RUN 7	RUN 8	AVG
ALUMINUM [a]	1134.74	274.40	134.53	514.56
ANTIMONY	2.95	11.69	1.54	5.39
ARSENIC [a]	6.59	5.11	1.21	4.30
BARIUM [a]	39.49	28.83	18.04	28.79
CADMIUM [a]	50.65	73.64	17.04	47.11
CALCIUM	1.62	5.34	0.18	2.38
CHROMIUM [b]	50.40	66.81	1.70	39.63
COBALT	200.75	0.00	0.00	66.92
COPPER [a]	0.97	0.34	0.03	0.45
GOLD [a]	0.00	0.00	ND	0.00
IRON [a]	2.05	2.43	0.21	1.56
LEAD [a]	15.48	4.22	1.10	6.94
MAGNESIUM [a]	2.16	3.18	0.22	1.85
MANGANESE	0.37	1.33	0.13	0.61
NICKEL	28.19	76.69	0.62	35.17
PHOSPHORUS	1.36	0.50	0.03	0.63
SELENIUM	327.50	ND	ND	327.50
SILVER	328.27	31.68	4.24	121.40
SODIUM [a]	5.92	1.84	0.32	2.69
SULFUR	3.02	5.23	0.88	3.05
TIN	5.78	0.77	0.00	2.18
TITANIUM [a]	1.36	0.64	0.23	0.74
VANADIUM	4.67	6.27	0.69	3.88
ZINC	4.15	9.30	1.31	4.92

[a] Results for one or more runs may have been affected by high filter blank result.

[b] Contamination of the probe + 10 μm catch may have occurred.

TABLE 26. TRACE METALS REMOVAL EFFICIENCIES FOR THE BAGHOUSE

	REMOVAL EFFICIENCY [a]			
METAL	RUN 6	RUN 7	RUN 8	AVERAGE
COPPER[b]	99.606	99.837	99.959	99.801
TITANIUM[b]	99.350	99.674	99.641	99.555
LEAD[b]	98.942	99.574	99.624	99.380
MAGNESIUM[b]	98.893	99.022	99.764	99.226
IRON[b]	99.017	98.798	99.741	99.185
CALCIUM	98.912	98.680	99.782	99.125
VANADIUM	99.599	98.167	99.350	99.039
SODIUM[b]	97.521	99.228	99.695	98.814
CADMIUM[b]	98.520	98.231	98.838	98.530
ARSENIC[b]	97.601	97.997	98.638	98.079
PHOSPHORUS	97.788	97.817	98.298	97.968
ZINC	98.105	95.739	98.103	97.316
GOLD[b]	100.000	100.000	91.776	97.259
MANGANESE	94.795	95.411	95.958	95.388
SILVER	92.739	90.607	99.579	94.308
TIN	93.107	91.738	97.952	94.266
ANTIMONY	98.702	94.484	82.972	92.053
NICKEL[b]	94.110	81.932	99.388	91.810
BARIUM[b]	88.643	94.122	88.247	90.337
CHROMIUM[d]	75.981	76.386	97.455	83.274
ALUMINUM[b,c]	--	--	--	--
COBALT[c]	--	--	--	--
SELENIUM[c]	--	--	--	--
SULFUR[c]	--	--	--	--

[a] Removal efficiency calculated as (1-(mass rate at outlet)/(mass rate at inlet)).

[b] Results for one or more runs may have been affected by high filter blank result.

[c] Negative removal efficiencies were calculated for one or more runs.

[d] Contamination of the probe + 10 µm catch may have occurred.

TABLE 27. SUMMARY OF TRACE METALS REMOVAL EFFICIENCIES FOR THE BAGHOUSE

< 65%	65 - 85%	85 - 95%	95 - 99%	> 99%
Selenium (-)	Chromium (83.3)[a]	Barium (90.3)[a]	Manganese (95.4)	Vanadium (99.0)
Sulfur (-)		Nickel (91.8)[a]	Gold (97.3)[a]	Calcium (99.1)
Aluminum (-)[a]		Antimony (92.1)	Zinc (97.3)	Iron (99.2)[a]
Cobalt (-)		Tin (94.3)	Phosphorus (98.0)	Magnesium (99.2)[a]
		Silver (94.3)	Arsenic (98.1)[a]	Lead (99.4)[a]
			Cadmium (98.5)[a]	Titanium (99.6)[a]
			Sodium (98.8)[a]	Copper (99.8)[a]

[a] Removal efficiencies may be inaccurate because of experimental uncertainties (see Table 25).

magnesium, lead, titanium, and copper.

Overall, the baghouse generally showed higher trace metal removal efficiencies than the scrubber(compare Tables 22 and 27). Fourteen of the 24 species analyzed for had baghouse removal efficiencies of 95 percent or greater, compared to 9 of 24 for the scrubber.

As might be expected, the baghouse was ineffective for controlling sulfur emissions from the incinerator. Much of the sulfur in the sludge feed is emitted as gaseous sulfur oxides. The toxic metals chromium (83.3%), nickel (91.8%), arsenic (98.1%), cadmium (98.5%), and lead (99.4%) all had baghouse removal efficiencies greater than 80 percent. Selenium was not detected in the uncontrolled incinerator emissions during the baghouse test runs. Excessive confidence should not be placed in the percent recovery values in light of the analytical uncertainties for many of the metals.

Distribution of Trace Metals by SASS Train Size Fraction. The distribution of trace metal emissions by SASS train size fraction at the baghouse outlet varied significantly between the 24 species analyzed. Since no particulate matter was captured in the 1 micron cyclone or the 3 micron cyclone at the baghouse outlet, the trace metals were distributed only among the probe rinse/10 micron cyclone catch, filter catch, and impinger catch. A table of fractional metals distribution data is contained in Appendix A for each test run. These data are summarized in Table 28. The distributions for chromium, iron, and nickel do not include the impinger catch results because of suspected stainless steel contamination, as discussed in Section 6. The distributions for several metals may be uncertain because of high filter blank results, as discussed in Section 6. These metals include aluminum, iron, magnesium, cadmium, sodium, titanium, lead, barium, arsenic, copper, and gold.

The data show that as a whole, trace metal emissions from the baghouse were more evenly distributed among the 3 SASS train size fractions than were the trace metal emissions from the scrubber. The major difference is that the impinger catch was a much more significant contributor to trace metals emissions from the baghouse than to trace metals emissions from the scrubber. The significance of this shift should not be overemphasized. It is primarily due to the extremely effective removal of the probe +10 μ m and the filter catch size range by the baghouse, which increased the relative magnitude of the impinger catch (see following section).

Sulfur, which was found to be the most abundant species analyzed for in the scrubber emissions, was distributed almost exclusively in the impinger fraction of the total SASS train catch. Less than 0.2 percent of the captured sulfur was found in the probe rinse/10 micron cyclone catch; less than 0.03 percent was found in the probe rinse/10 micron cyclone catch; less than 0.03 percent was found in the filter catch; and greater than 99.8 percent was found in the impinger catch.

As a whole, the trace metals (i.e., non-sulfur species) emitted by the baghouse were distributed primarily in the probe rinse/10 micron cyclone catch and the impinger catch. Excluding aluminum, approximately 38 percent of the

TABLE 28. AVERAGE TRACE METALS PARTICLE SIZE DISTRIBUTIONS FOR THE CONTROLLED BAGHOUSE EMISSIONS

	BAGHOUSE OUTLET		
	PROBE + 10 um	FILTER CATCH	IMPINGER CATCH
ALUMINUM[a]	1.53	98.47	0.00
ANTIMONY	34.67	8.10	57.23
ARSENIC[a]	25.61	74.39	0.00
BARIUM[a]	15.19	84.81	0.00
CADMIUM[a]	73.47	15.81	10.72
CALCIUM	83.69	0.00	16.31
CHROMIUM[b,c]	100.00	0.00	--
COBALT	28.31	0.00	71.69
COPPER[a]	68.23	31.77	0.00
GOLD[a]	0.00	100.00	0.00
IRON[a,b]	78.60	21.40	--
LEAD[a]	17.14	82.86	0.00
MAGNESIUM[a]	59.96	34.76	5.29
MANGANESE	4.00	1.10	94.90
NICKEL[b]	92.90	7.10	--
PHOSPHORUS	10.39	7.94	81.67
SELENIUM	3.72	0.36	95.92
SILVER	82.17	17.83	0.00
SODIUM[a]	58.90	41.10	0.00
SULFUR	0.14	0.02	99.83
TIN	0.00	3.76	96.24
TITANIUM[a]	35.26	64.74	0.00
VANADIUM	91.59	8.41	0.00
ZINC	89.43	2.91	7.66

[a] Results of one or more runs may have been affected by high filter blank result.

[b] Results of impinger catch not included because of suspected stainless steel contamination.

[c] Contamination of the probe + 10 μm catch may have occurred.

total trace metals concentration was found in the probe rinse/10 micron cyclone catch; 10 percent was found in the filter catch; and 52 percent was found in the impinger catch. This represents a significant difference from the trace metals distribution of the scrubber emissions, which was skewed towards the filter fraction.

The probe rinse/10 micron cyclone catch represented the largest fraction of the SASS train catch for 11 individual species. These were calcium, zinc, magnesium, cadmium, sodium, copper, vanadium, chromium, iron, nickel, and silver. The filter catch represented the largest fraction of the SASS train catch for size individual species: aluminum, titanium, lead, barium, arsenic, and gold. The impinger catch represented the largest fraction of the SASS train catch for seven individual species.

COMPARISON OF SCRUBBER AND BAGHOUSE PERFORMANCE

In this section, the effectiveness of the scrubber and the baghouse in reducing total particulate and trace metals emissions from the incinerator are compared. It should be noted that absolute comparisons are not possible since the scrubber and the baghouse did not treat exactly the same gas stream (i.e., the baghouse slipstream may not have been completely representative of the scrubber inlet emissions). Also, since the scrubber and baghouse tests were performed on different days, variations in sludge feed characteristics and incinerator operating conditions could also obscure differences in performance between the two units.

Total Particulate Removal Capability

The total particulate emissions from the scrubber were higher than those from the baghouse. The average total particulate removal efficiency of the scrubber was 94.3 percent, while the baghouse averaged 99.1 percent. As discussed below, these differences were primarily attributed to the relative performance of the two control devices on particulate matter in the filter fraction of the SASS train catch.

Both the scrubber and the baghouse showed high removal efficiencies for large particulate. Removal efficiencies for particulate matter in the probe rinse/10 micron cyclone fraction of the SASS train catch were 97.7 percent for the scrubber and 98.6 percent of the baghouse. No measurable particulate matter was captured in the 3 micron and 1 micron SASS train cyclones at the outlet from either control device. Thus, both the scrubber and the baghouse exhibited nearly complete removal for particulate matter in these size fractions. The difference in the overall particulate removal efficiencies of the scrubber and the baghouse is due to differences in effectiveness on the filter fraction of the SASS train catch. The scrubber removed only 59 percent of the particulate matter in the filter catch size fraction, while the baghouse removed 98.6 percent. Removal efficiencies for particulate matter in the back half of the SASS train (i.e., the impingers) were not measured.

Trace Metals Removal Capability

The baghouse and the scrubber were both reasonably effective in controlling trace metals emissions from the incinerator. As shown in Table 29, control efficiencies for the toxic species cadmium, lead, nickel, chromium, and arsenic exceeded 82 percent for both devices. The data show that the baghouse was more effective than the scrubber for controlling emissions of arsenic, cadmium, and lead, while the scrubber was more effective for controlling emission of chromium and nickel. As noted earlier (see Tables 20 and 25), these conclusions are uncertain for some of these metals.

The distribution of trace metal emissions in the SASS train size fractions was similar for the two control devices for the trace metals except cadmium. Cadmium emissions from the scrubber were found primarily on the filter catch, whereas emissions from the baghouse were found primarily in the probe/10 micron cyclone catch. For the both the scrubber and baghouse, arsenic and lead were found primarily in the filter catch and chromium and nickel were found primarily in the probe/10 micron cyclone catch. However, it should be noted that the impinger catch results for chromium and nickel are not included because of suspected stainless steel contamination.

Other Considerations

Other factors that should be considered in comparing the relative performance of the baghouse and the scrubber are emissions of gas phase species. The scrubber was clearly superior to the baghouse in reducing emissions of sulfur-containing species, most of which are assumed to be sulfur oxides. The scrubber had a removal efficiency greater than 99 percent for sulfur-containing species, while the baghouse showed essentially no removal capability for these species.

Controlled emissions of hydrocarbon species were not measured at the baghouse outlet location. However, based on visual observations it appeared that a significant amount of hydrocarbons were emitted by the baghouse. The scrubber would be expected to be more effective than the baghouse in reducing these emissions.

TRACE METALS CONTENT OF BOTTOM ASH AND BAGHOUSE DUST

The trace metals content of incinerator bottom ash and baghouse dust samples from each test run are presented in Appendix A. The metals content data are reported on a dry, volatile free basis. Table 30 shows the measured total solids and volatile solids contents of the bottom ash and baghouse catch samples. Dry, volatile-free solids accounted for an average of 99.6 weight percent of the bottom ash samples and 86.5 weight percent of the baghouse dust samples.

The dry, volatile-free metals analyses of the bottom ash samples are summarized in Table 31. The average trace metals contents of the bottom ash samples were generally similar to that of the dry, volatiles free sludge. The

TABLE 29. COMPARISON OF BAGHOUSE AND SCRUBBER REMOVAL EFFICIENCIES FOR SELECTED METALS

Species	Removal Efficiency (%)	
	Baghouse	Scrubber
Arsenic[a]	98.1	96.5
Cadmium [a]	98.5	82.0
Chromium[a,b]	83.3	83.8
Lead[a]	99.4	86.5
Nickel[a]	91.8	94.0
Selenium	--	--

[a] Results of one or more runs may have been affected by a high filter blank result.

[b] Contamination of the probe + 10 μm catch may habe occurred. Contamination would inflate estimated losses, reducing calculated removal efficiencies.

TABLE 30. TOTAL SOLIDS AND VOLATILES CONTENT DATA FOR THE PROCESS SAMPLES

Sample	Total Solids Content of Sample (wt.%)	Volatiles Content of Solids (wt.%)
Sludge Feed Samples		
Sludge Feed, Run 03	14.3	62.0
Sludge Feed, Run 04	15.3	61.6
Sludge Feed, Run 05	13.9	65.4
Sludge Feed, Run 06[a]	14.4	59.8
Sludge Feed, Run 06[a]	14.7	60.9
Sludge Feed, Run 07	15.5	12.8
Sludge Feed, Run 08	16.3	13.5
Bottom Ash Samples		
Bottom Ash, Run 02	99.9	0.2
Bottom Ash, Run 03	99.7	0.3
Bottom Ash, Run 04[a]	99.4	0.3
Bottom Ash, Run 04[a]	99.4	0.3
Bottom Ash, Run 06	100.0	0.1
Bottom Ash, Run 07	100.0	0.2
Bottom Ash, Run 08	100.0	0.3
Baghouse Dust Samples		
Baghouse Dust, Run 06	92.5	6.8
Baghouse Dust, Run 07[a]	93.1	6.7
Baghouse Dust, Run 07[a]	92.8	6.8
Baghouse Dust, Run 08	92.6	6.4

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[a] Duplicate analyses were performed on the following sample:

Sludge feed, Run 06; Bottom Ash, Run 04; and Baghouse Dust, Run 07.

TABLE 31. TRACE METALS CONTENT OF BOTTOM ASH

CONCENTRATION OF TRACE METALS IN BOTTOM ASH
PPM

	RUN 2	RUN 3	RUN 4	RUN 6	RUN 7	RUN 8	AVERAGE
ALUMINUM	4.15E+03	2.23E+03	2.06E+03	1.74E+03	7.78E+02	1.24E+03	2.03E+03
ANTIMONY	2.48E+02	2.28E+02	2.31E+02	2.21E+02	2.16E+02	2.20E+02	2.27E+02
ARSENIC	7.49E+02	7.49E+02	7.67E+02	6.71E+02	6.07E+02	7.07E+02	7.08E+02
BARIUM	2.83E+02	8.90E+01	1.10E+02	7.56E+01	9.29E+01	1.09E+02	1.27E+02
CADMIUM	1.06E+02	4.14E+01	1.07E+02	5.82E+01	6.00E+01	9.54E+01	7.79E+01
CALCIUM	4.95E+04	9.84E+03	3.63E+04	3.59E+04	3.07E+04	3.57E+04	3.30E+04
CHROMIUM	5.27E+02	4.44E+02	5.37E+02	4.50E+02	4.16E+02	4.62E+02	4.73E+02
COBALT	5.07E+01	4.14E+01	4.44E+01	3.44E+01	3.26E+01	4.31E+01	4.11E+01
COPPER	4.82E+03	4.99E+03	5.37E+03	4.50E+03	4.23E+03	5.08E+03	4.83E+03
GOLD	1.02E+01	1.07E+01	8.31E+00	7.02E+00	2.32E+00	6.87E+00	7.58E+00
IRON	5.72E+04	4.99E+04	5.77E+04	4.54E+04	4.26E+04	5.64E+04	5.15E+04
LEAD	8.52E+02	6.22E+02	6.43E+02	4.64E+02	4.34E+02	7.16E+02	6.22E+02
MAGNESIUM	1.84E+04	7.65E+03	1.23E+04	1.08E+04	1.05E+04	1.52E+04	1.25E+04
MANGANESE	4.37E+02	3.48E+02	4.27E+02	3.01E+02	2.92E+02	3.61E+02	3.61E+02
NICKEL	2.92E+02	1.29E+02	2.47E+02	1.68E+02	1.37E+02	2.19E+02	1.99E+02
PHOSPHOROUS	7.50E+04	7.99E+04	8.16E+04	6.75E+04	6.27E+04	6.15E+04	7.14E+04
SELENIUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SILVER	3.68E+01	6.46E+01	5.23E+01	3.08E+01	1.48E+01	1.20E+01	3.52E+01
SODIUM	5.06E+03	3.42E+03	5.55E+03	4.32E+03	3.61E+03	5.13E+03	4.51E+03
SULFUR	4.15E+03	2.89E+03	4.17E+03	4.38E+03	6.03E+03	6.05E+03	4.61E+03
TIN	3.39E+02	2.89E+02	3.14E+02	2.89E+02	2.37E+02	2.89E+02	2.93E+02
TITANIUM	7.83E+03	7.81E+03	8.06E+03	6.75E+03	6.20E+03	7.03E+03	7.28E+03
VANADIUM	7.14E+02	5.45E+02	5.21E+02	4.24E+02	3.63E+02	4.89E+02	5.09E+02
ZINC	6.74E+03	6.25E+03	6.57E+03	5.65E+03	5.53E+03	6.57E+03	6.22E+03

average trace metals concentrations of the bottom ash and sludge samples agreed to within 30 percent except for 5 species. The non-volatile species aluminum, barium, and silver were found to be significantly more abundant in the bottom ash relative to the sludge. The bottom ash enrichment ratios of these species were respectively 1.9, 1.5, and 4.5. Cadmium and sulfur, on the other hand, were significantly less abundant in the bottom ash than in the sludge. The bottom ash enrichment ratios of these species were 0.36 and 0.19 respectively.

The baghouse dust is an almost total collection of the particles in the uncontrolled emissions from the incinerator. Analytical problems in determining metal concentrations are minimized because samples taken for analysis can be sufficiently large that trace contamination from equipment is made trivial. Consequently the baghouse dust should give an excellent picture of the composition of the uncontrolled emissions. The metals contents of the dry volatiles-free baghouse dust is summarized in Table 32. The metals contents are similar to the results obtained by the SASS train at the baghouse inlet (Appendix Tables 6.1B-8.1B). Enrichment ratios calculated from volatile-free feed concentrations (Table 5) and the SASS train and baghouse metals concentrations are compared in Table 33. Except for a few metals (barium, gold, magnesium, and silver), the agreement is good. The agreement of the results between the results of the baghouse "total catch" method and the SASS train results strongly supports the validity of the SASS train method.

Sulfur shows an enrichment factor for the baghouse close to the SASS train factor and both are close to unity. This appears to be an anomalous result in considering earlier evidence presented that indicated large losses of sulfur for the baghouse, but further consideration indicates the result is reasonable. First, the results for ash show that the enrichment of sulfur in the ash is much less than unity. Most of the sulfur evidently goes overhead. A high enrichment factor in the uncontrolled emissions would be expected, but the SASS train result shows an enrichment factor of only 0.75. However, it must be recalled that the calculation of the enrichment factor does not include material in the impingers where most of the sulfur was found. The baghouse is ineffective in collecting sulfur dioxide, so it should show an enrichment factor close to the SASS value, which it does.

CONTINUOUS MONITORING DATA

Mean concentrations of the combustion gases that were continuously monitored at the incinerator outlet location are shown for each test run in Table 34. The overall mean values of the valid data for each parameter are: oxygen, 11.2 percent by volume (dry); carbon monoxide, 3500 ppmv (dry); carbon dioxide, 8.1 percent by volume (dry); sulfur oxides, 500 ppmv (dry); nitrogen oxides, 200 ppmv (dry); and total hydrocarbons, 88 ppmv (wet, as propane).

The continuous oxygen monitoring data for Runs 03 and 07 were considered invalid for several reasons: (i) the continuous monitoring data for these runs did not agree with integrated bag sample data analyzed using a gas chromatograph; (ii) the continuous oxygen monitoring data for these runs did

TABLE 32. TRACE METALS CONTENT OF BAGHOUSE DUST

CONCENTRATION OF TRACE METALS IN BAGHOUSE DUST
PPM

	RUN 6	RUN 7	RUN 8	AVERAGE
ALUMINUM	2.94E+03	1.48E+03	5.03E+03	3.15E+03
ANTIMONY	1.58E+02	2.13E+02	2.47E+02	2.06E+02
ARSENIC	8.20E+02	7.62E+02	9.13E+02	8.32E+02
BARIUM	7.95E+01	5.82E+01	7.90E+00	4.85E+01
CADMIUM	4.96E+03	4.10E+03	3.06E+03	4.04E+03
CALCIUM	5.66E+04	3.92E+04	5.24E+04	4.94E+04
CHROMIUM	6.71E+02	5.53E+02	4.62E+02	5.62E+02
COBALT	4.53E+01	4.35E+01	3.63E+01	4.17E+01
COPPER	4.88E+03	5.10E+03	4.75E+03	4.91E+03
GOLD	2.42E+00	2.68E+00	0.00E+00	1.70E+00
IRON	6.60E+04	6.28E+04	6.36E+04	6.41E+04
LEAD	4.18E+03	1.54E+03	8.82E+01	1.94E+03
MAGNESIUM	6.20E+03	1.45E+04	3.43E+02	7.01E+03
MANGANESE	3.84E+02	3.77E+02	3.06E+02	3.56E+02
NICKEL	3.97E+02	3.38E+02	1.45E+02	2.93E+02
PHOSPHOROUS	6.09E+04	5.97E+04	6.11E+04	6.06E+04
SELENIUM	1.36E+01	6.56E+01	0.00E+00	2.64E+01
SILVER	4.25E+00	1.60E+00	1.61E+00	2.49E+00
SODIUM	6.96E+03	2.79E+03	2.67E+03	4.14E+03
SULFUR	2.60E+04	2.26E+04	2.11E+04	2.32E+04
TIN	1.07E+03	8.45E+02	9.10E+02	9.41E+02
TITANIUM	6.15E+03	6.81E+03	6.51E+03	6.49E+03
VANADIUM	9.10E+02	7.47E+02	6.73E+02	7.76E+02
ZINC	7.99E+03	7.22E+03	6.24E+03	7.15E+03

TABLE 33

Comparison of Enrichment Ratios for Uncontrolled Emissions Calculated from SASS Train Results and the Baghouse Catch

	Average Enrichment Ratio	
	SASS	Baghouse
Aluminum	2.84[a]	2.89
Antimony	1.11	0.98
Arsenic	1.43	2.22
Barium	2.33	0.58
Cadmium	24.4	18.6
Calcium	1.82	1.18
Chromium	1.25	1.51
Cobalt	1.26	1.16
Copper	1.21	1.07
Gold	1.76	0.46
Iron	1.16	1.11
Lead	5.99	2.84
Magnesium	1.56	0.44
Manganese	1.30	1.18
Nickel	2.17[a]	2.50
Phosphorus	0.88	0.95
Selenium	-	1.69
Silver	14.03	0.31
Sodium	1.40[a]	1.02
Sulfur	0.76	0.95
Tin	4.54	3.40
Titanium	1.08	0.95
Vanadium	3.26	1.75
Zinc	1.29	1.16

[a] Results for one or more of the 3 runs comprising the average may have been affected by a high filter blank result.

TABLE 34. MEAN VALUES AND STANDARD DEVIATIONS OF THE CONTINUOUSLY MONITORED COMBUSTION GASES AT THE INCINERATOR OUTLET LOCATION

Parameter	Baghouse Test Runs			Scrubber Test Runs		
	Run 02	Run 03	Run 04	Run 06	Run 07	Run 08
O_2 (% Vol)	10.5 (1.1)	6.8[a] (1.9)	11.2 (0.5)	11.3 (1.7)	11.9 (0.9)	5.2[a] (2.2)
CO (ppmv)	526.8 (305.9)	11210.4 (23763.4)	685.8 (36.6)	2421.6 (553.9)	b	2649.3 (279.8)
CO_2 (% Vol)	9.0 (1.1)	8.7 (1.3)	7.5 (1.0)	8.8 (1.6)	8.0 (0.9)	6.8 (0.9)
SO_2 (ppmv)	506.4 (72.7)	404.0 (130.9)	341.1 (241.2)	591.2 (175.8)	655.7 (92.8)	493.3 (78.6)
NO_x (ppmv)	207.9 (10.7)	c	214.1 (9.9)	227.4 (32.3)	108.2 (70.7)	239.3 (116.9)
THC (ppmv as propane)	29.5 (8.7)	39.4 (18.2)	80.0 (62.6)	117.6 (33.5)	84.9 (44.8)	176.6 (141.4)

[a] Continuous oxygen monitoring data for Runs 03 and 08 are considered invalid (see discussion in text).
[b] Continuous carbon monoxide monitoring data for Run 07 were not obtained due to instrument malfunction.
[c] Continuous nitrogen oxide monitoring data for Run 03 are considered invalid (see discussion in text).

NOTE: Mean values shown on top, with standard deviation below in parenthesis.

All concentrations expressed on a dry volume basis except for total hydrocarbon concentrations, which are expressed on a wet volume basis (as propane).

not check with the continuous carbon monoxide monitoring data (i.e., the data did not follow combustion material balance guidelines); and (iii) there were no process operation changes expected to have caused significant changes in excess air.

Five-minute average values for the continuously monitored combustion gases are tabulated in Appendix B and are shown graphically as functions of time in Figures 15 through 26. These graphs show that there were significant temporal variations in the concentration of each of the monitored species.

DISPERSION MODELING PARAMETERS

Dispersion modeling parameters for the existing wet scrubber system and a hypothetical full scale baghouse system are listed in Table 35. Parameters for the scrubber are based on measured data from Runs 02 to 04 (scrubber test runs), adjusted slightly for the presence of the slipstream during the test runs. Parameters for the hypothetical full scale baghouse were based on the following six assumptions:

i) The baghouse stack height and diameter were assumed identical to that of the existing scrubber stack.

ii) The baghouse stack temperature was calculated based on a heat balance. The outlet baghouse temperature was assumed to be 400°F, the shaft cooling air outlet temperature was assumed to be 260°F (i.e., average for Runs 02 to 04) and the incinerator: shaft cooling air flow ratio was assumed identical to that of Figure 8.

iii) The baghouse stack moisture was calculated based on the average incinerator outlet moisture for Runs 02 to 04 (31.2% H_2O) and the incinerator: shaft cooling air flow ratio of Figure 8.

iv) The dry standard baghouse stack gas flow rate was assumed to be equal to that of the scrubber. The actual baghouse stack gas flow rate was calculated using the temperature and moisture values from (ii) and (iii) above.

v) The percent oxygen at the baghouse stack (dry basis) was assumed to be equal to that of the scrubber.

vi) Sludge feed rates were assumed to be equal to that of the scrubber.

The information in Table 35 combined with emissions concentrations could be used in dispersion models to estimate concentrations of metals at ground level for the two types of air pollution control devices.

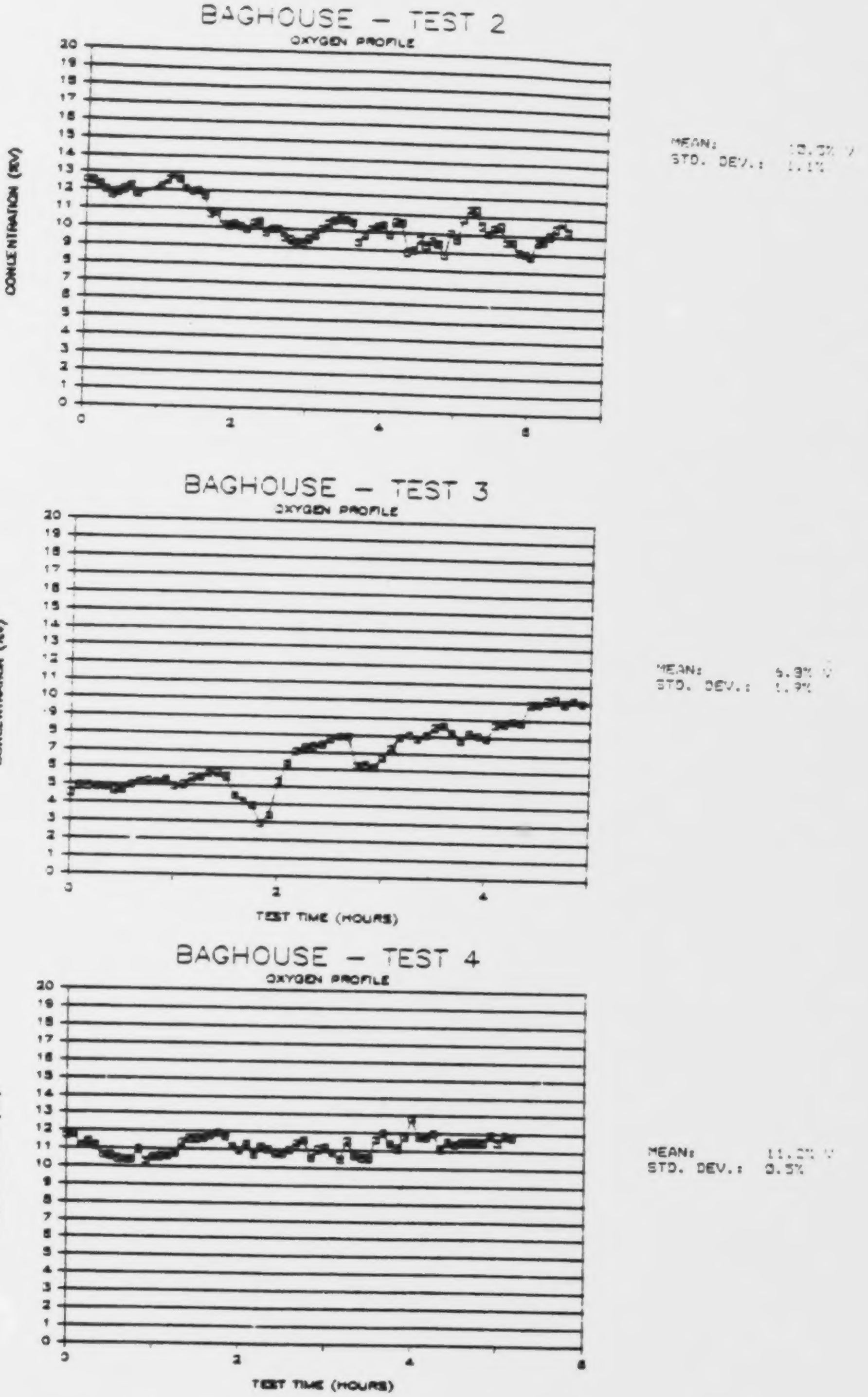
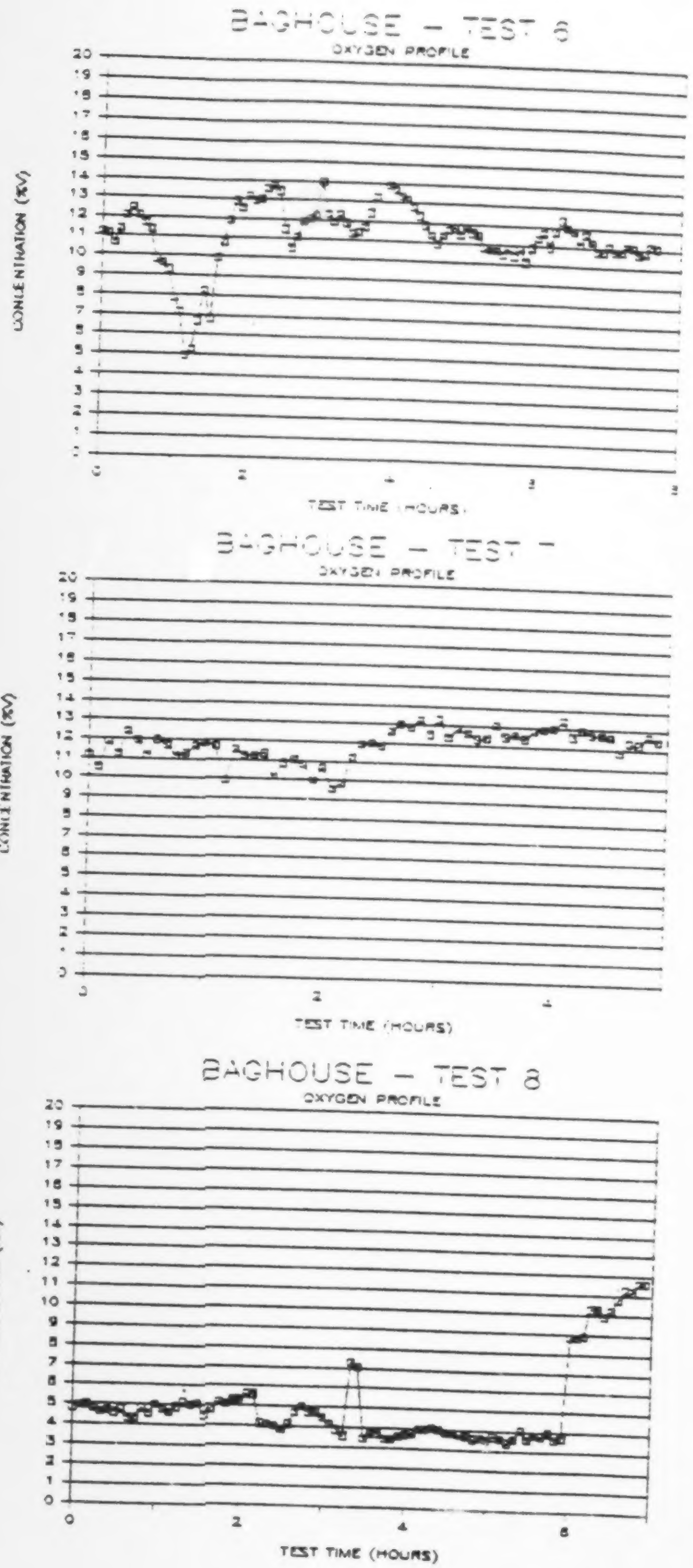


Figure 15. Continuous Oxygen Monitoring Data--Scrubber Test Runs

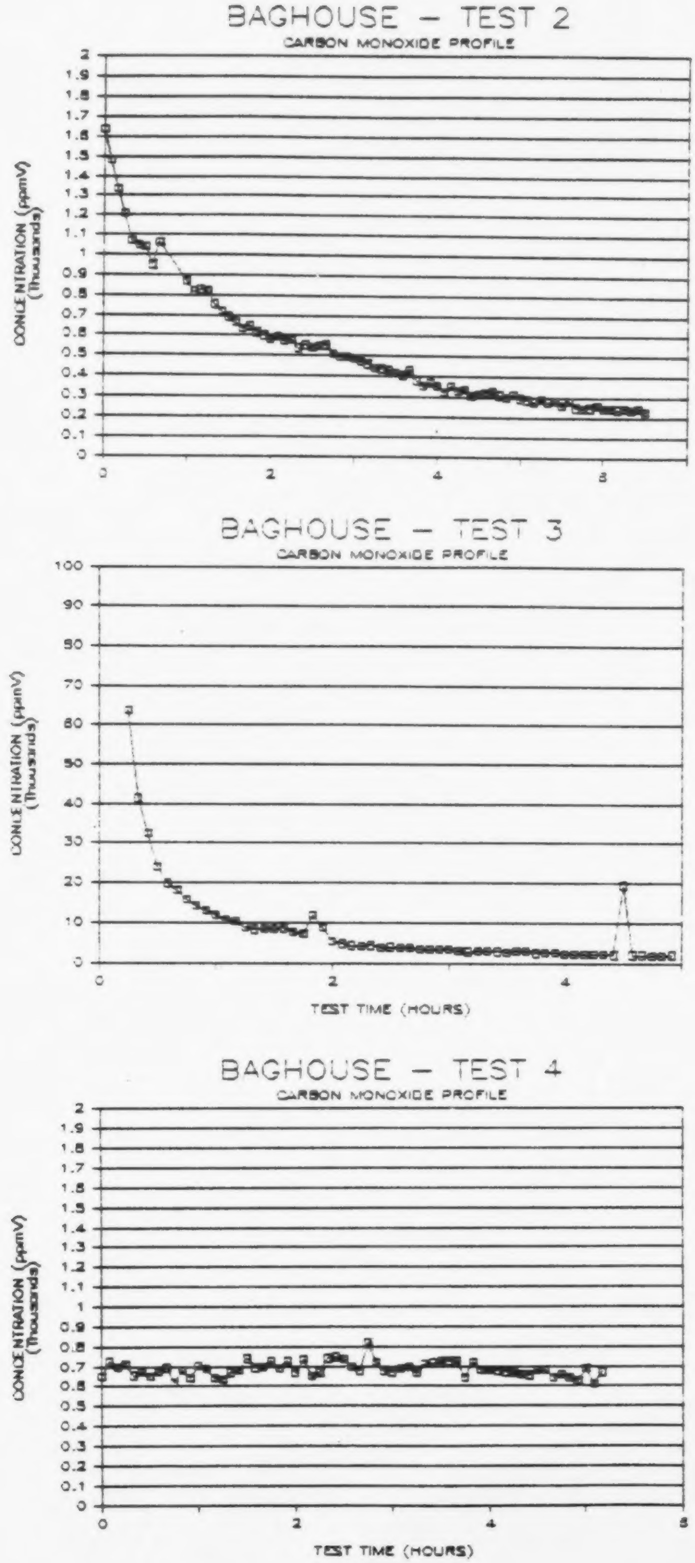


MEAN: 11.3% V
STD. DEV.: 1.7%

MEAN: 11.8% V
STD. DEV.: 0.8%

MEAN: 5.0% V
STD. DEV.: 2.2%

Figure 16. Continuous Oxygen Monitoring Data--Baghouse Test Runs


BAGHOUSE – TEST 2
CARBON MONOXIDE PROFILE

MEAN: 526.8 ppmV
STD. DEV.: 385.9

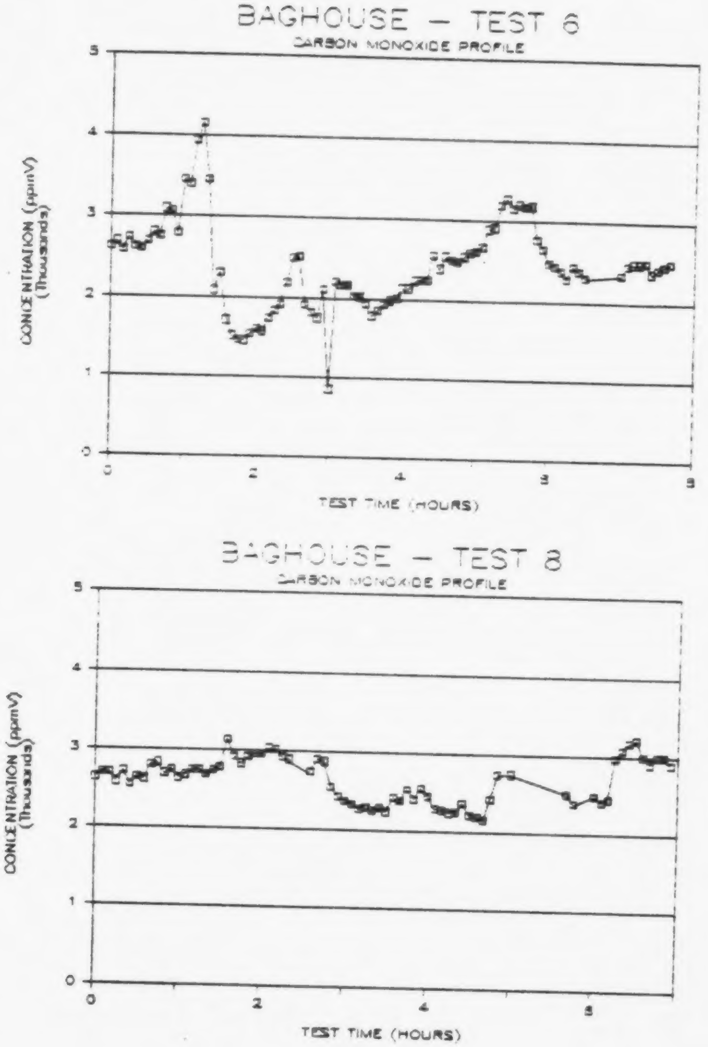
BAGHOUSE – TEST 3
CARBON MONOXIDE PROFILE

MEAN: 11212.4 ppmV
STD. DEV.: 23767.4

BAGHOUSE – TEST 4
CARBON MONOXIDE PROFILE

MEAN: 685.9 ppmV
STD. DEV.: 36.6

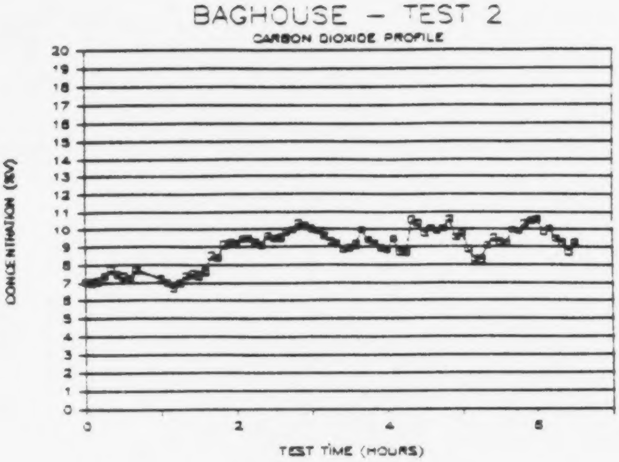
Figure 17. Continuous Carbon Monoxide Monitoring Data--Scrubber Test Runs



MEAN: 2421.6 ppmV
STD. DEV.: 553.9

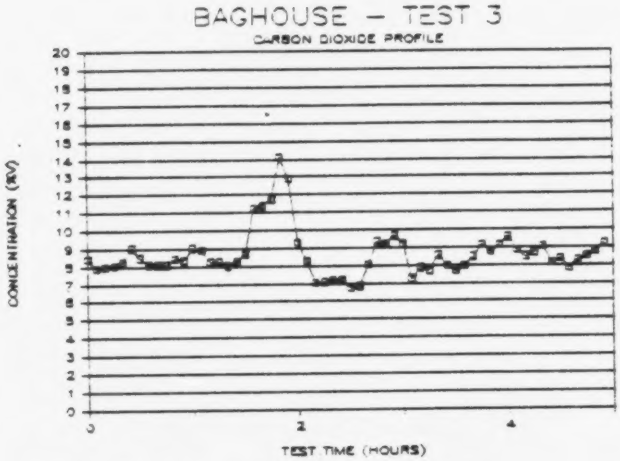
MEAN 2619.3 ppmV
STD. DEV.: 279.8

Figure 18. Continuous Carbon Monoxide Monitoring Data--Baghouse Test Runs


BAGHOUSE - TEST 2

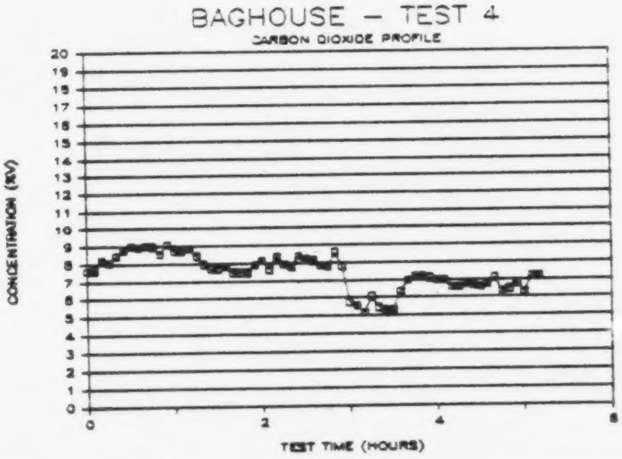
CARBON DIOXIDE PROFILE

MEAN: 9.3% V
STD. DEV.: 1.1%


BAGHOUSE - TEST 3

CARBON DIOXIDE PROFILE

MEAN: 8.7% V
STD. DEV.: 1.3%


BAGHOUSE - TEST 4

CARBON DIOXIDE PROFILE

MEAN: 7.5% V
STD. DEV.: 1.0%

Figure 19. Continuous Carbon Dioxide Monitoring Data--Scrubber Test Runs

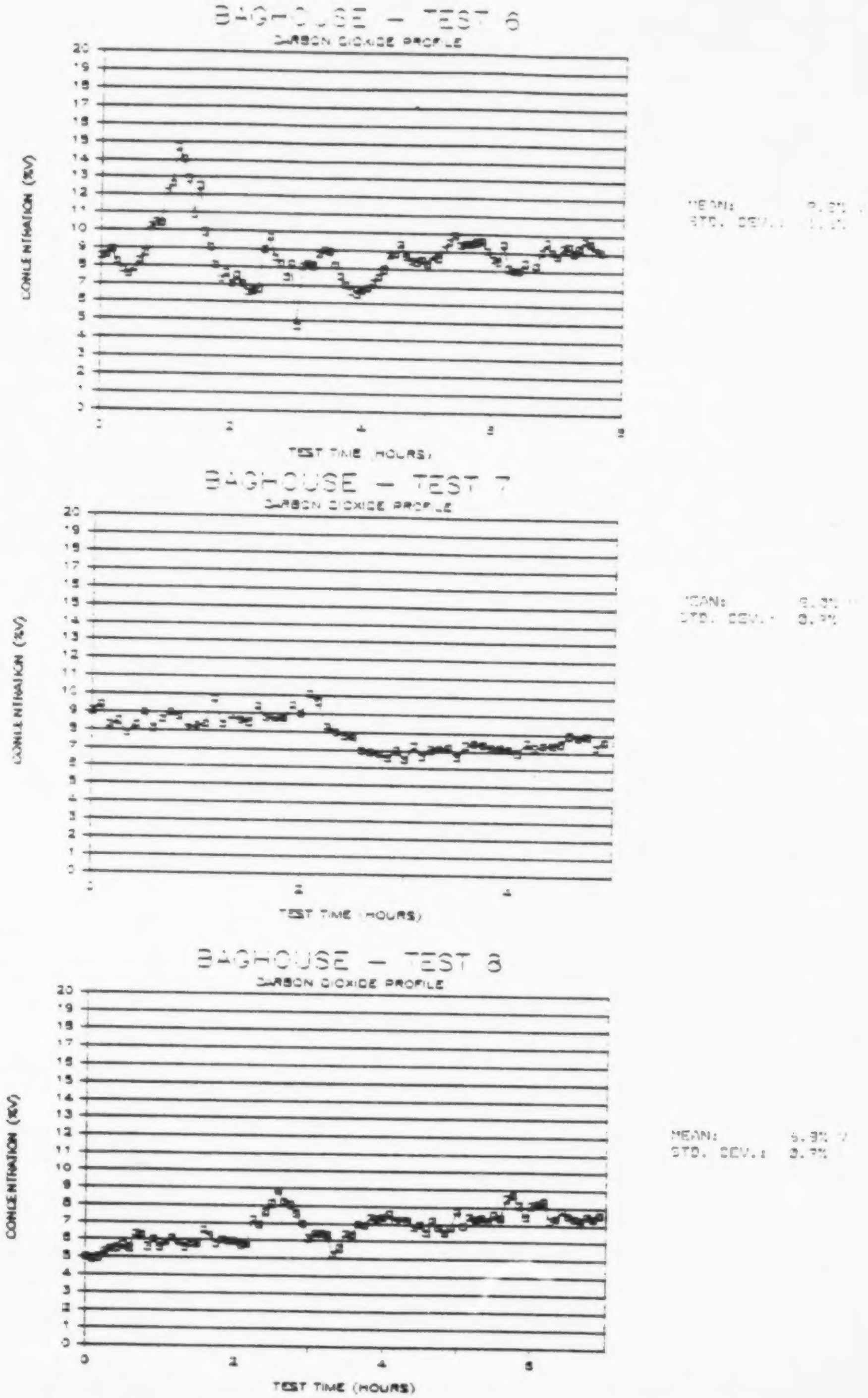


Figure 20. Continuous Carbon Dioxide Monitoring Data--Baghouse Test Runs

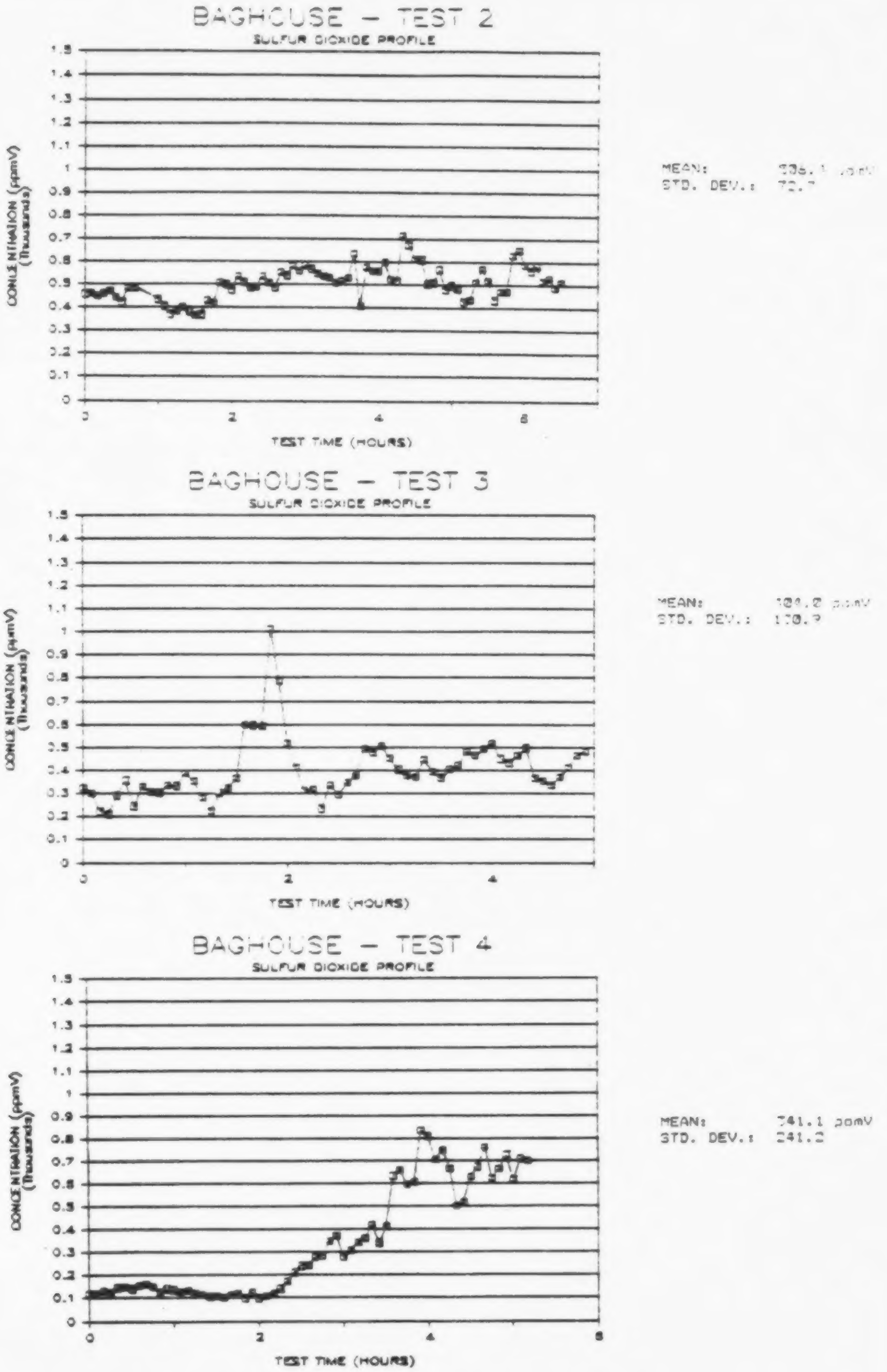


Figure 21. Continuous Sulfur Dioxide Monitoring Data--Scrubber Test Runs

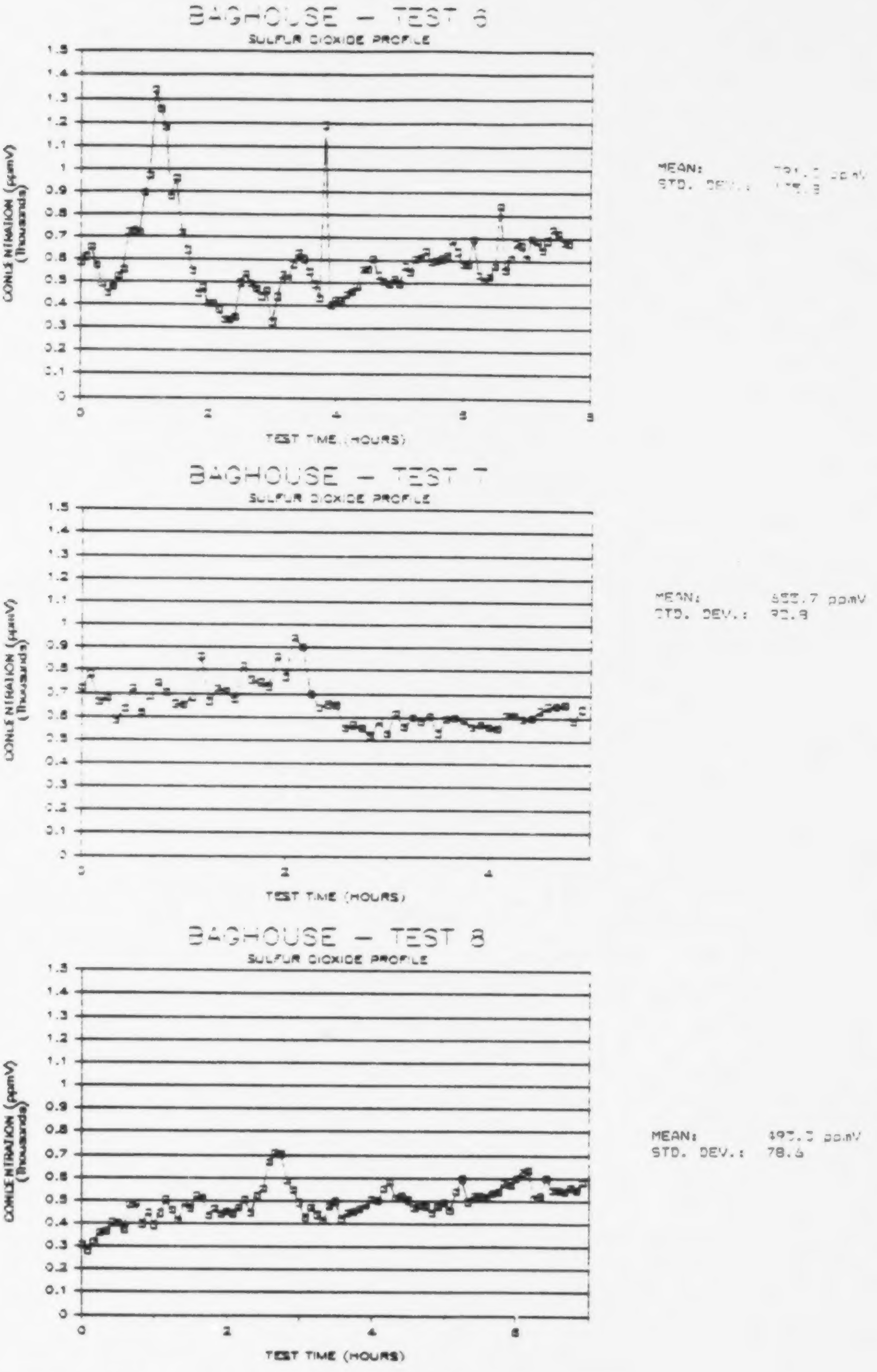
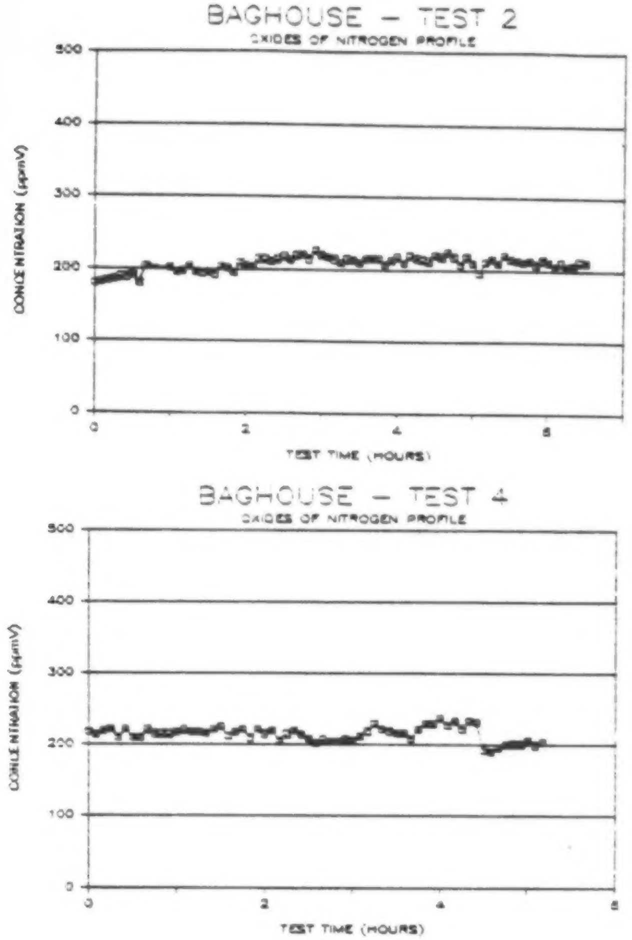


Figure 22. Continuous Sulfur Dioxide Monitoring Data--Baghouse Test Runs



MEAN: 207.9 ppmV
STD. DEV.: 10.7

MEAN: 214.1 ppmV
STD. DEV.: 9.9

Figure 23. Continuous Nitrogen Oxides Monitoring Data--Scrubber Test Runs

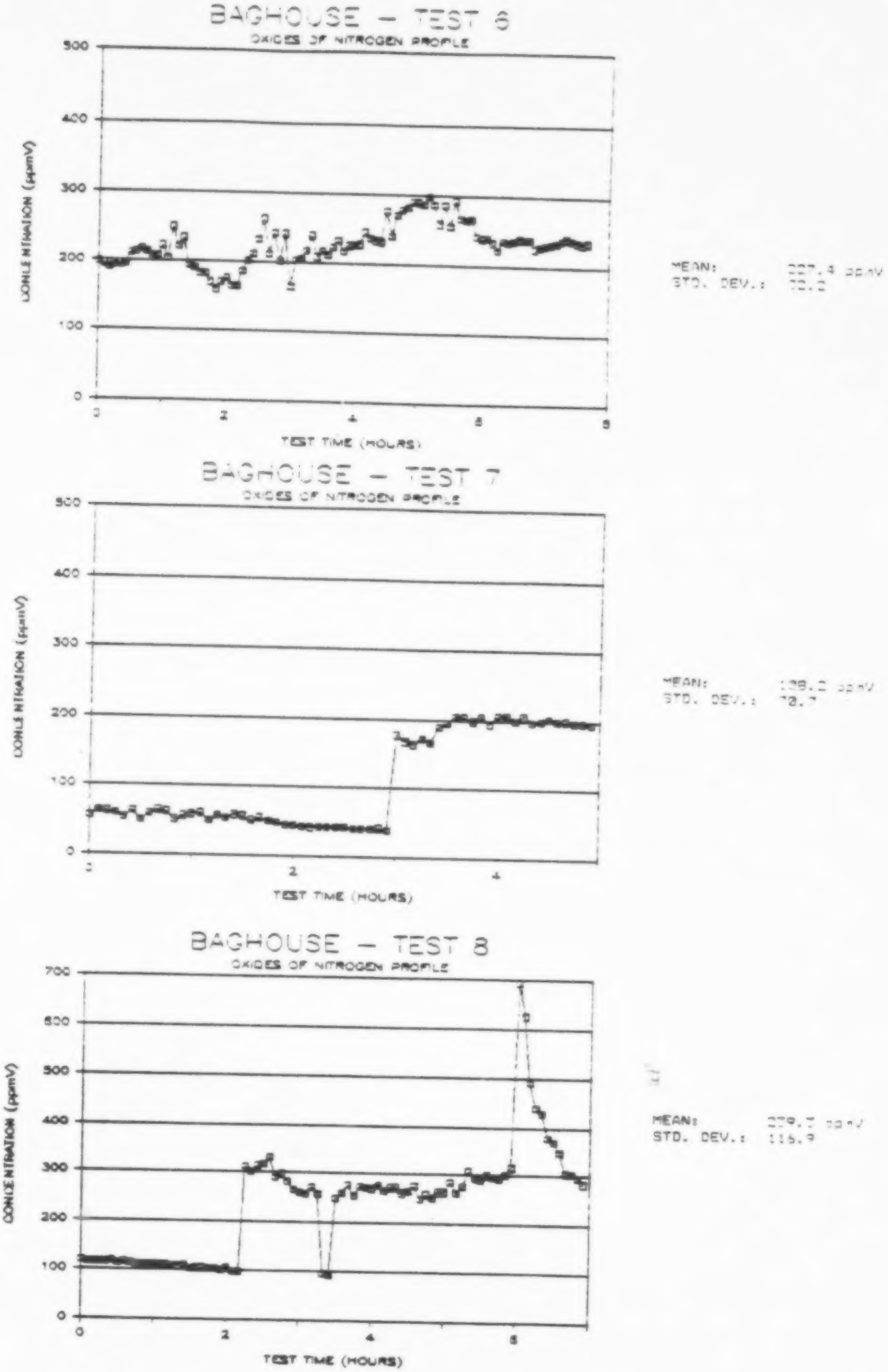
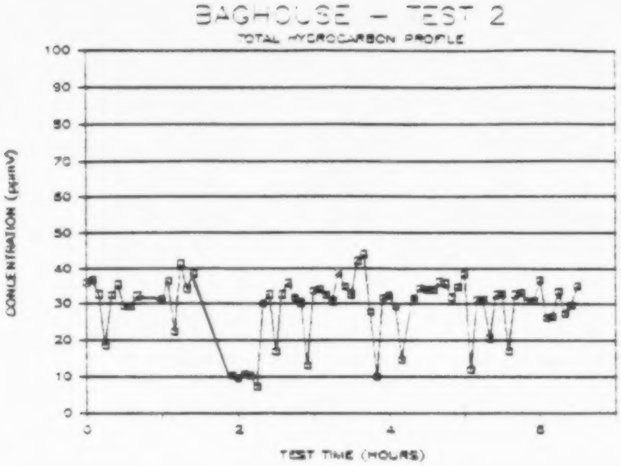
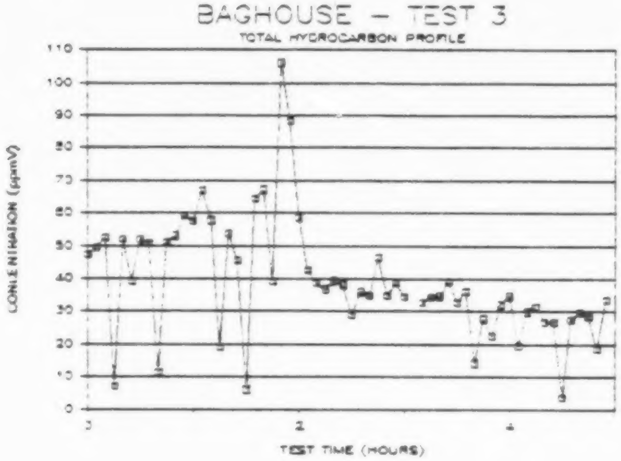


Figure 24. Continuous Nitrogen Oxides Monitoring Data--Baghouse Test Runs


BAGHOUSE - TEST 2

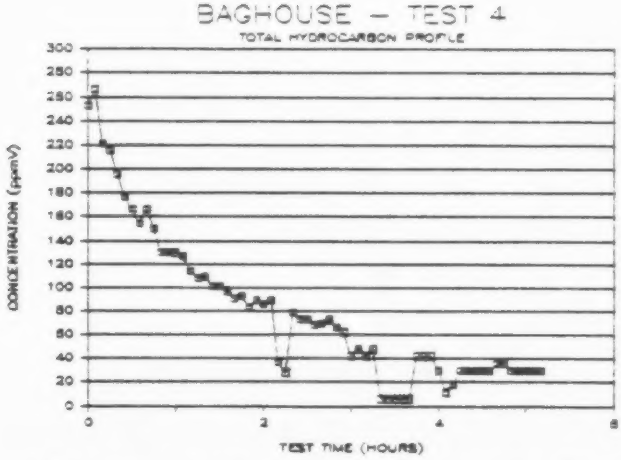
TOTAL HYDROCARBON PROFILE

MEAN: 29.3 ppmV
STD. DEV.: 8.7


BAGHOUSE - TEST 3

TOTAL HYDROCARBON PROFILE

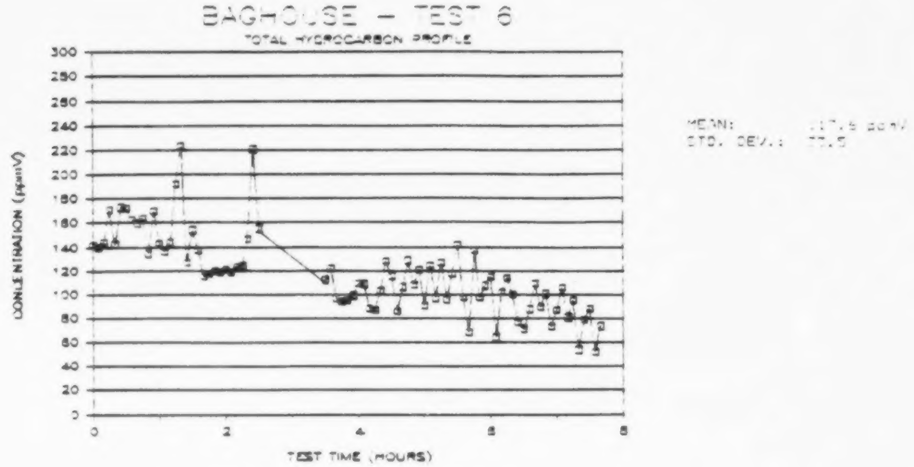
MEAN: 39.4 ppmV
STD. DEV.: 18.2

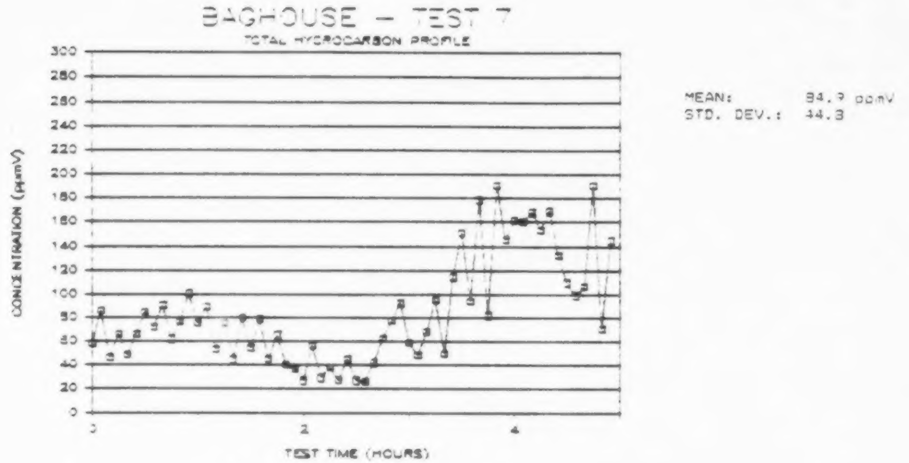

BAGHOUSE - TEST 4

TOTAL HYDROCARBON PROFILE

MEAN: 30.0 ppmV
STD. DEV.: 62.6

Figure 25. Continuous Total Hydrocarbon Monitoring Data--Scrubber Test Runs





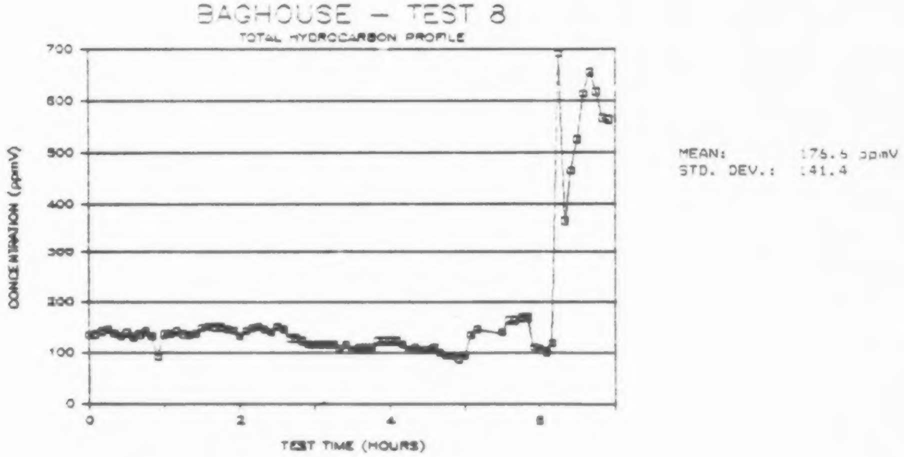


Figure 26. Continuous Total Hydrocarbon Monitoring Data--Baghouse Test Runs

TABLE 35. Dispersion Modeling Parameters for the Scrubber and a Full Scale Baghouse

	Scrubber[a]	Baghouse[b]
Stack Height (above ground level)	22.0 m	22.0 m
Stack Diameter (inside)	1.2 m	1.2 m
Stack Temperature (outlet)	75°C	112°C
Stack Moisture (outlet)	2.5 %	14.7 %
Stack Gas Flow (dry standard)	234 dscmm	234 dscmm
Stack Gas Flow (actual conditions)	285 acmm	353 acmm
% O_2 (dry)	17.8 %	17.8 %
Sludge Feed Rate (wet basis)	1680 kg/hr	1680 kg/hr
Sludge Feed Rate (dry basis)	280 kg/hr	280 kg/hr

[a] Modeling parameters for the scrubber system were developed from data measured during Runs 02-04, adjusted by the slipstream volume.

[b] Modeling parameters for the full scale baghouse system were calculated as discussed in the text.

SECTION 4

SAMPLING PROCEDURES

This section describes the flue gas sampling and process sampling methods used during the scrubber and baghouse tests.

SASS TRAIN SAMPLING PROCEDURE

This section contains the SASS train sampling description that was originally included in the site specific test plan. The procedures specified in the test plan were carefully followed during the scrubber and baghouse test runs. For additional details on the sampling train, see the Operating and Service Manual: Source Assessment Sampling System. A schematic diagram of the SASS train is shown in Figure 27.

Equipment Preparation for Sample Collection

The first stage in preparing a new sampling train and new sample containers for sample collection is prepassivation with a nitric acid solution. All metal and glass surfaces in the sampling train that come in contact with the sample will be prepassivated by a 30-min contact with 15 percent (v/v) aqueous nitric acid. Use a stiff nylon brush or hard Teflon scraper to aid in cleaning the surfaces if necessary. Agitate the parts initially to remove trapped air bubbles. Rinse in a second solution of 15 percent (v/v) HNO_3, then rinse with distilled water. Next, rerinse by spraying thoroughly with alcohol (taking care to cover all surfaces) or dip in alcohol and agitate for 10 seconds. Finally, dry in clean air. If the impingers are to be used immediately after cleaning, they should be thoroughly dried or rerinsed with distilled water to prevent foaming.

A different approach is used for subsequent cleanings of SASS train components and the sample bottles for the baghouse test program. In the lab, the sampling train components and sample bottles are cleaned in three successive stages using a different solvent in each stage. The solvents are hot soapy water, distilled water, 0.1 normal nitric acid, and acetone in the order listed. This will remove all extraneous particulate matter and produce a clean, dry surface. A contaminated train component may not be used in a sampling run. All equipment treated in the above fashion must be placed in a clean area to await the test.

The field area in which the sample clean-up operations are performed must be as clean as possible under existing field conditions. An enclosed space is required in which reasonable precaution has been taken to remove spurious dust, dirt, or particulate contaminants. Reasonable precaution is intended to mean that the area has been swept clean, doors or other significant draft-inducing sources have been closed, and all work bench areas have been wiped down.

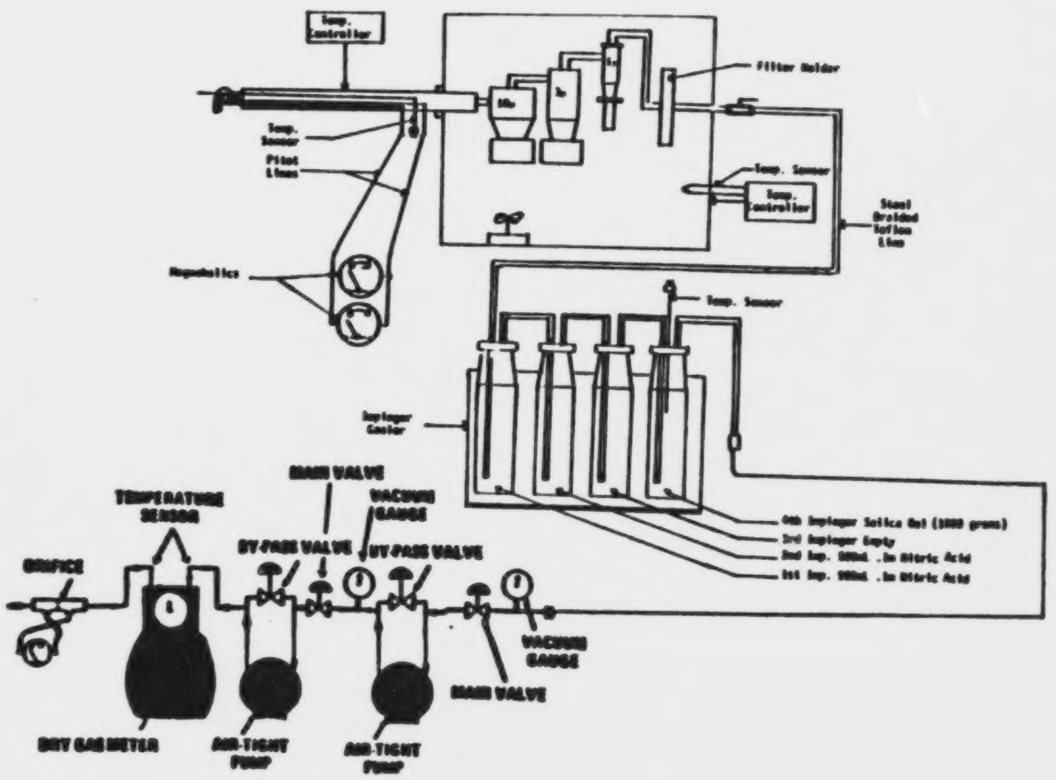

Temp. Controller
Temp. Sensor
Pitot Lines
Magnehelics
10μ
3μ
1μ
Filter Holder
Temp. Sensor
Temp. Controller
Steel Braided Teflon Line
Temp. Sensor
Impinger Cooler
4th Impinger Silica Gel (1000 grams)
3rd Impinger Empty
2nd Imp. 500ml .1m Nitric Acid
1st Imp. 500ml .1m Nitric Acid
ORIFICE
TEMPERATURE SENSOR
DRY GAS METER
BY-PASS VALVE
MAIN VALVE
VACUUM GAUGE
BY-PASS VALVE
AIR-TIGHT PUMP
AIR-TIGHT PUMP
MAIN VALVE
VACUUM GAUGE

Figure 27. Source assessment sampling train (SASS) schematic.

Apparatus Checkout - SASS Test

The following tasks will be performed in the home base laboratory prior to testing:

a. Assemble all components required for the complete system.

b. Clean components in accordance with the procedures described in reference manual.

c. Obtain a sufficient quantity of solvents to maintain adequate reserves during the elapsed time in the field.

d. Accumulate an inventory of Swagelok fittings for each SASS train.

e. Examine all SASS train parts closely for defects that might induce down-time problems in the field.

f. Leak-check the entire system.

Next to the cleaning procedures, leak-checking the train prior to field use is one of the most important pretest tasks to be performed. This procedure can save many hours in the field. The leak-checking procedure involves assembling the entire train, sealing the probe tip, opening the isolation ball valve, turning on the pumping system, and observing flow meter gauges for the existence of any appreciable flow. Evacuate the train to 127 mm Hg (5 in Hg). The allowable leak rate for the SASS train is 0.0014 m^3/min (0.05 ft^3/min) at this pressure. Close the isolation ball valve and leak check the remainder of the train at 508 mm Hg (20 in Hg). The leak rate should again be less than 0.0014 m^3/min (0.05 ft^3/min). If this criterion is not easily achievable using Teflon gaskets in the system, Viton A gasket substition may facilitate meeting this standard. The instructions accompanying the train present in detail the steps involved in leak-checking the system.

SASS Train Sampling Procedure

The SASS sample is normally acquired at a point of average velocity near the center of the duct (the average velocity being determined by a velocity traverse). During the baghouse test program the sample will be drawn from single points. Sample point location will be determined either by EPA Method 1 specifications or in the center of the duct depending on velocity stratification, access and sample time. The sample will be withdrawn at a constant flow rate using a nozzle that is specifically selected for near isokinetic conditions (± 20%) when the test is initiated. Nozzle selection will be determined from preliminary measurements at each location.

The steps involved in using the train to acquire this sample are described in detail in the manuals provided with the SASS train. An outline of the procedure follows:

I. Test Site

   A. Prepare sampling port on duct, flue, or stack.

   B. Secure electrical power.

II. SASS Train Assembly

A. Attach probe to oven.

B. Place the three cyclones and filter assembly in the oven and connect the 10 um cyclone to the probe. (Note that to achieve the proper size fractionation, the vortex breakers for the ">10 um" and for the "10- to 3-um" cyclones should not be used.)

C. Assemble impinger train.

1. Fill impinger bottles with the reagents listed in Table 36.
2. Place the impingers in the tray in impinger case, cap bottles, and make appropriate connections.
3. Transport to sampling location.
4. Fill impinger case with ice and water.

D. Connect oven outlet (i.e., filter housing outlet) to the first impinger.

E. Connect vacuum pumps (in parallel) to the last impinger outlet.

F. Connect all temperature sensors and power lines to control unit.

III. Checkout and Inspection

A. Run gas flow leak check.

B. Check temperature indicators with all thermocouples at ambient temperature.

C. Heat oven and probe to 204^{o}C (400^{o}F).

D. Note operation of vacuum pumps and gas meter.

E. Inspect pitot tube; also, compare results of volume measured with orifice meter and dry gas meter. Calibrate each as necessary.

IV. Operation

A. Measure stack temperature, moisture content, and velocity profile.

B. Calculate size of probe nozzle needed for isokinetic sampling and select and attach appropriate size nozzle. The stack temperature, gas velocity, and effluent water vapor content must be considered when choosing the proper nozzle size (preliminary measurement).

C. Calculate train gauge reading to achieve train flow rate of 0.184 ACMM (6.5 ACFM) in the cyclones. (This flow rate is necessary for proper operation of the cyclones.)

TABLE 36. SASS TRAIN IMPINGER SYSTEM REAGENTS

Impinger	Reagents	Quantity	Purpose
#1	Nitric acid (0.1N HNO_3)	500 mL	Condense moisture and metals
#2	Nitric acid (0.1N HNO_3)	500 mL	Condense moisture and metals
#3	Empty	Empty	Prevent carryover
#4	Silica gel	1500 grams	Condense moisture and protect pump/dry gas meter

D. Install probe in stream at desired point and turn on vacuum pumps; adjust train flow rate to the calculated desired rate.

E. If the flow rate cannot be maintained at greater than 75 percent of the desired rate, the filter must be changed.

F. Collect sample. Monitor all temperatures and flow rates, and adjust as necessary.

V. Shutdown

A. Close valves at pumps.

B. Remove the sampling nozzle train from inside the stack.

C. Turn off pumps.

D. Switch off main power.

Replacement of a clogged filter is a time-consuming process that could require as much as 2 hours, depending on the sampling location and the possible difficulties that can be encountered in exchanging the filter housings. Once removed, the housing should be carried intact to a clean area for filter removal. A second, preloaded filter housing should be available for use when the first filter housing is removed for unloading, cleaning, adn reloading. Check this assembled replacement filter assembly for leaks before placing it in service, then make a final check of the pressure drop of the whole SASS system when the unit is again reassaembled. The 1 um cyclone reservoir should be checked for remaining capacity whenever the filter is replaced. Take care not to contaminate the contents during this inspection.

Sample Handling and Shipment

A modular approach will expedite the explanation of the procedures involved in sample transfer and handling. For this reason, the SASS train is considered in terms of the following sections:

a. Nozzle and probe
b. Cyclone system interconnect tubing
c. Cyclones
d. Filter
e. Impingers

At the conclusion of the sampling run, the train is disassembled and transported to the mobile lab unit or prepared work area as follows:

a. Open the cyclone oven to expedite cooling, disconnect the probe, and cap off both ends.

b. Disconnect the line joining the cyclone oven to impinger assembly at the exit side of the filter and cap off (1) the entrance to the 10-um cyclone, (2) the filter holder exit, and (3) the entrance to the joining line, which was disconnected from the filter holder exit point.

c. Cap off the entrance line to the impinger system.

d. Disconnect the line leaving the silica gel impinger at its exit point and cap off the impinger exit. Discard ice and water from the impinger box to facilitate carrying.

At the completion of all sample transfer activities, all SASS train components must be completely clean in preparation for the next sampling run.

SASS Sample Recovery

Figure 28 is a flowchart of the sample handling for those SASS fractions containing particulate matter. Each glass container with the individual cyclone catches will be dessicated and weighed separately. All front half components of the SASS sampling train, including the probe, cyclone(s) and filter assembly will be rinsed with acetone after cyclone sample recovery. A second rinse with 0.1N nitric acid will be used to insure removal of residual metal species. Both rinses will be retained for analysis. The acetone rinses for all stages will be combined and evaporated to dryness, dessicated and weighed. The four (4) individual stage weights will be summed with the combined acetone evaporate and totaled for the front half mass particulate determination.

Figure 29 is a flowchart of the sample handling for the impinger contents. The impinger catch will be used to determine moisture and condensed metals analysis of metal content will be performed on the impinger contents. An empty third impinger has been added to ensure adequate condensation of moisture from the sample stream. The fourth impinger will contain silica gel (1500 grams).

Continuous Monitoring of Combustion Gases

Continuous monitoring was performed at the incinerator outlet (scrubber inlet) sampling location for O_2, CO_2, CO, NO_x, SO_2, and THC. The continuous monitoring was performed throughout the 6-hour period that SASS train sampling was being conducted each test day. Sample acquisition was accomplished using an in-stack filter probe and 24 m (80 ft) of heat-traced Teflon sample line connected to a mobile laboratory. The heat traced sample line was maintained at a temperature of 150°C (300°F) to prevent condensation in the sample line. The stack gas sample was drawn through the filter and heated sample line using pumps located in the mobile laboratory. Sample gas to be analyzed for CO, CO_2, O_2, NO_x and SO_2 was then pumped through a sample gas conditioner, consisting of an ice bath and knockout trap, to remove moisture and thus provide a dry gas stream for analysis. A separate unconditioned gas slip stream was supplied to the THC analyzer for analysis on a wet basis.

An Anarad Model 412 nondispersive infrared (NDIR) analyzer was used to measure CO and CO_2; a Beckman Model 755 paramagnetic analyzer was used to measure O_2; a Teco Model 10 chemiluminescent analyzer was used to measure NO_x; a Teco Model 40 pulsed fluorescence analyzer was used to measure SO_2; and a Beckman Model 402 flame ionization was used to measure THC. The calibration procedures for the continuous monitors included a three point (two upscale plus zero) linearity check on the first test day, single point and zero calibration checks daily, and single point drift check at the end of each test day.

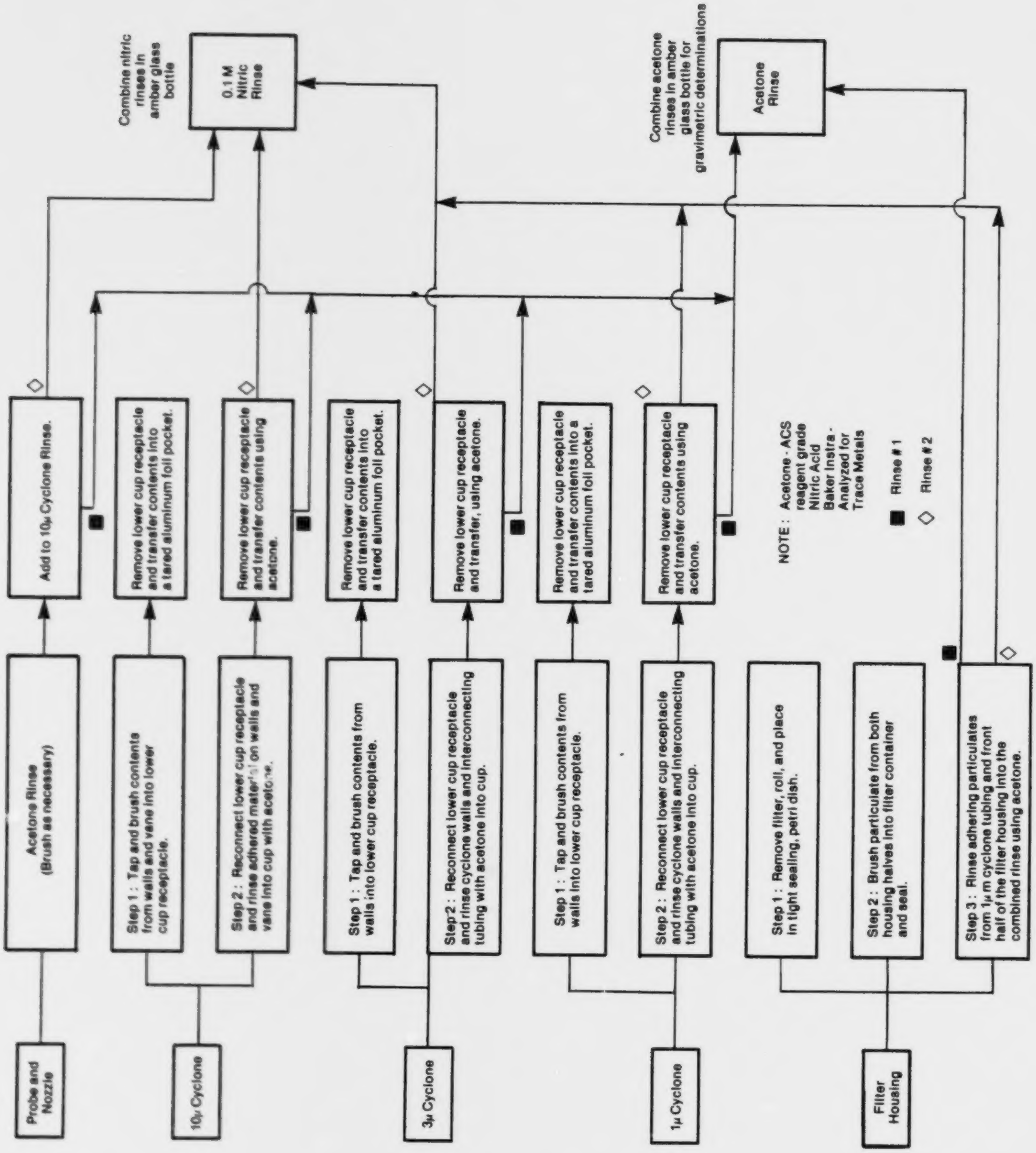

Probe and Nozzle
Acetone Rinse (Brush as necessary)
Add to 10μ Cyclone Rinse.
10μ Cyclone
Step 1 : Tap and brush contents from walls and vane into lower cup receptacle.
Remove lower cup receptacle and transfer contents into a tared aluminum foil pocket.
Step 2 : Reconnect lower cup receptacle and rinse adhered material on walls and vane into cup with acetone.
Remove lower cup receptacle and transfer contents using acetone.
3μ Cyclone
Step 1 : Tap and brush contents from walls into lower cup receptacle.
Remove lower cup receptacle and transfer contents into a tared aluminum foil pocket.
Step2 : Reconnect lower cup receptacle and rinse cyclone walls and interconnecting tubing with acetone into cup.
Remove lower cup receptacle and transfer, using acetone.
1μ Cyclone
Step 1 : Tap and brush contents from walls into lower cup receptacle.
Remove lower cup receptacle and transfer contents into a tared aluminum foil pocket.
Step 2 : Reconnect lower cup receptacle and rinse cyclone walls and interconnecting tubing with acetone into cup.
Remove lower cup receptacle and transfer contents using acetone.
Filter Housing
Step 1 : Remove filter, roll, and place in tight sealing, petri dish.
Step 2 : Brush particulate from both housing halves into filter container and seal.
Step 3 : Rinse adhering particulates from 1μ m cyclone tubing and front half of the filter housing into the combined rinse using acetone.
0.1 M Nitric Rinse
Combine nitric rinses in amber glass bottle
Acetone Rinse
Combine acetone rinses in amber glass bottle for gravimetric determinations
NOTE : Acetone - ACS reagent grade
Nitric Acid Baker Instra - Analyzed for Trace Metals
■ Rinse # 1
◇ Rinse # 2

Figure 28. Sample handling and transfer - nozzle, probe, cyclones, and filter.

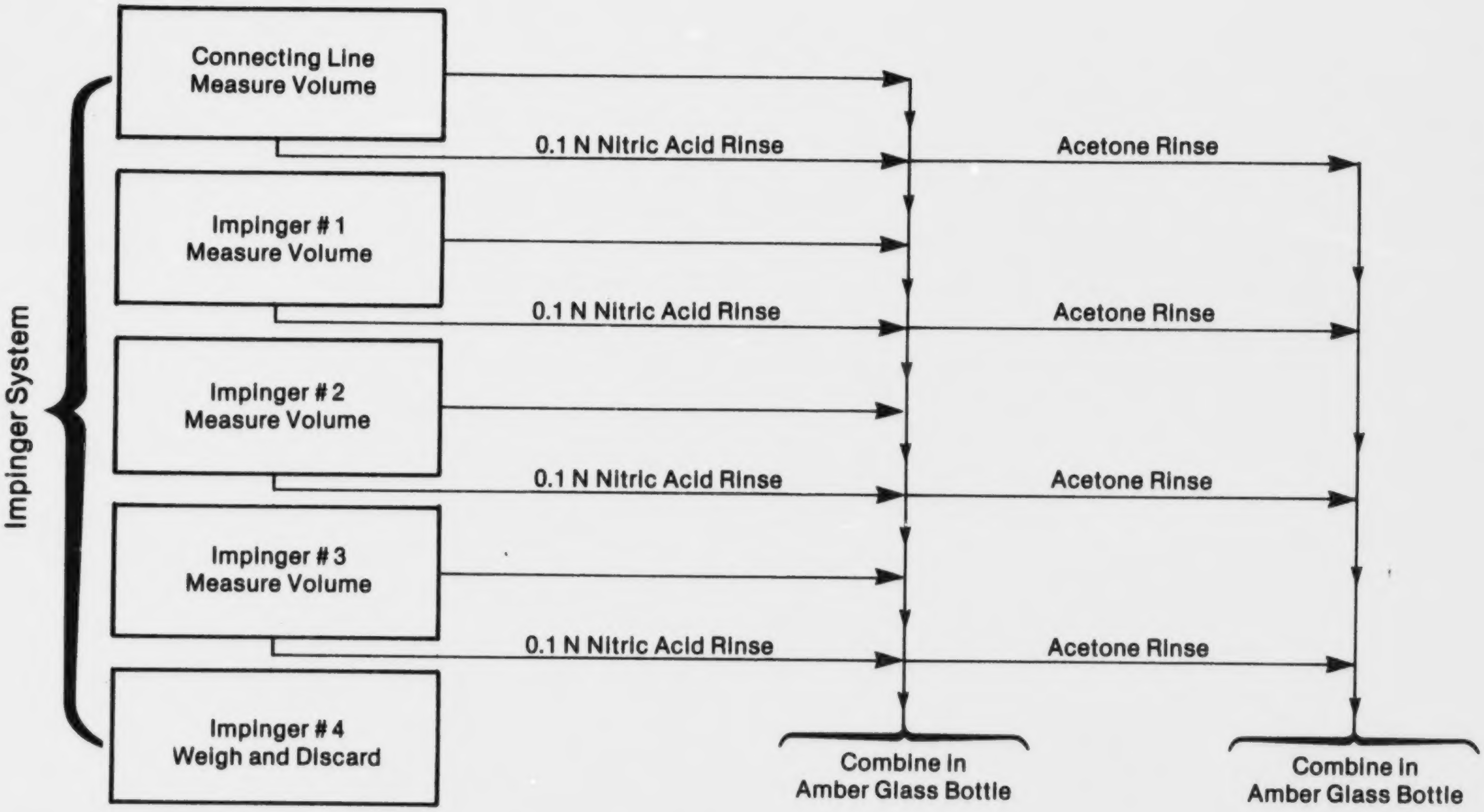

Impinger System
Connecting Line
Measure Volume
Impinger # 1
Measure Volume
Impinger # 2
Measure Volume
Impinger # 3
Measure Volume
Impinger # 4
Weigh and Discard
0.1 N Nitric Acid Rinse
0.1 N Nitric Acid Rinse
0.1 N Nitric Acid Rinse
0.1 N Nitric Acid Rinse
Acetone Rinse
Acetone Rinse
Acetone Rinse
Acetone Rinse
Combine In
Amber Glass Bottle
Combine In
Amber Glass Bottle

Figure 29. Sample handling and transfer - SASS impingers.

STATIONARY GAS SAMPLING AND MOISTURE DETERMINATION

The integrated sampling technique described in EPA Method 3 was used at the SASS sampling locations to obtain a composite flue gas sample for fixed gas (O_2, CO_2, N_2) analysis. The fixed gas analysis was used to determine the molecular weight of the gas stream and to correct the measured particulate and trace metal concentrations to 12% O_2. A small diaphragm pump and a stainless steel probe were used to extract single point flue gas samples. The samples were collected in a Tedlar^R bag. Moisture was removed from the gas sample by a water-cooled condenser so that the fixed gas analysis was on a dry basis. The composition of the stationary gas sample was determined using a Shimadzu Model 3BT analyzer instead of the Fyrite or Orsat analyzer prescribed in EPA Method 3. The Shimadzu instrument employs a gas chromatograph and a thermal conductivity detector to determine the fixed gas composition of the sample.

The moisture content of the flue gas was determined at the SASS sampling locations using EPA Method 4. Based on this method, a measured volume of particulate-free gas was pulled through a chilled impinger train. The quantity of condensed water was determined gravimetrically and then related to the volume of gas sampled to determine the moisture content.

PROCESS SAMPLES

Three types of process samples were obtained: incinerator sludge feed, incinerator bottom ash, and baghouse dust. Sampling locations and procedures are discussed below.

Sludge Feed Sampling

Sludge feed samples were obtained directly from the belt feeder immediately prior to the incinerator. The host plant routinely samples the sludge on an hourly basis and analyzes the 24-hour sample composites for total solids and volatile solids. Plant personnel were asked to take additional samples for the test program at the same time they took samples for solids/volatiles analyses. Each hourly test sample consisted of approximately 500g (1.1 lb) of sludge. The hourly samples were composited in a large clear glass jar. The composite sample from each run was analyzed for metals content using ICAP spectroscopy.

Incinerator Bottom Ash Sampling

Incinerator bottom ash was sampled at the point of discharge from the screw conveyor that transports the ash from the bottom hearth of the incinerator. The ash was sampled as it was discharged into a large hopper. A pre-cleaned metal bucket attached to a long handle was used for the sampling. The bucket was held directly below the spout to capture the falling bottom ash.

A 1 liter composite bottom ash sample was developed for each test run. The composite samples were prepared from two 250 ml samples taken at the beginning and end of each run. The composite bottom ash sample from each run was analyzed for metals content using ICAP spectroscopy.

Baghouse Dust Sampling

Particulate matter captured by the baghouse was recovered at the end of each test run by manually brushing the exterior surface of the bags with a soft brush. The particulate matter then fell to the bottom of the baghouse and settled in a glass collection jar. The contents of the collection jar were removed at the end of each test run. The baghouse particulate matter catch from each of the baghouse test runs (Runs 04-06) was analyzed for metals content using ICAP spectroscopy.

SECTION 5

ANALYTICAL PROCEDURES

SAMPLES PREPARATION FOR ICAP ANALYSIS

Samples collected in the SASS sampling train were analyzed for total particulate concentration, particle size distribution, and metals content. Metals were analyzed by ICAP after weighing the samples on a 5-place analytical balance. Sludge feed, bottom ash, and hopper catch samples were analyzed for metals after the sample preparation desribed below. Daily composites of one-hour increments of sludge were analyzed by the host sites laboratory for moisture and volatiles content. The same procedures were used for both the baghouse and the ESP evaluations.

Three types of samples were generated: (i) liquid, (ii) particulate and (iii) filter with particulate. The individual samples taken are as follows: probe rinse, ten micron cyclone catch, 3 micron cyclone catch, 1 micron cyclone catch, filter, impinger contents, incinerator bottom ash, hopper catch, and sludge feed.

Aliquots of the impinger contents were analyzed by ICAP as is. Aliquots were removed from a well mixed sample. Prior to analysis the sludge feed, bottom ash, and hopper catch samples were dried at 100°C until a constant weight was achieved. Following the drying, these samples were ashed at 600°C to drive off any volatile organics. Aliquots for further samples preparation were taken from the 100°C dried samples for the bottom ash and hopper catch, while the sludge feed aliquot was taken from the 600°C ashed sample.

All particulate samples were digested in acid using a Parr bomb having a Teflon container, prior to analysis by ICAP. The particulate samples include the filter, 1 micron cyclone catch, 3 micron cyclone catch, 100°C dried bottom ash, 100°C dried hopper catch, and 600°C ashed sludge feed. In all possible cases, the dried probe rinse was added to the 10 micron cyclone catch and well mixed, from which an aliquot was taken and digested. After either a filter sample was folded and placed in a Teflon container, or 0.5 g to 1 g of a particulate sample was weighed into a teflon container, 5 ml of concentrated HF was added. This was followed by 5 ml of concentrated HNO_3. The container was then placed into the bomb casing, sealed, and put in an oven at 150°C for 4 to 6 hours. After digestion, the bombs were cooled and opened. The liquid solution was poured into a 50 ml Nalgene volumetric flask and brought to volume with deionized water. The 50 ml samples were then ready for analysis.

If any residue remained, the liquid was carefully decanted and the residue was filtered through glass wool and rebombed with 5 ml of HF and 5 ml of HNO_3. This ensured that all metals were leached into solution from the particulate. Almost all the filter samples had residue remaining after the first bombing, while the other samples did not. This is likely due to the greater amount of material which was to be digested: Not only was 0.5 g to 1.5 g of sample present, but also 1.0 g to 2.0 of glass fiber filter. After redigestion, the rebombed residue samples were analyzed as separate samples, but the results were combined with that from the first bombing.

METALS ANALYSIS BY ICAP

All metals analyses were performed on an Instrumentation Laboratory inductively coupled Argon Plasma 200 (ICAP), having a vacuum monochrometer. Samples are analyzed by aspirating a sample into the ICAP's plasma or torch. The torch destroys any compounds, leaving all metals present in their atomic or ionic state. The metal atoms or ions absorb energy from the torch, which is given off by the atom or ion as light. This light then passes through both a vacuum monochrometer and an airpath monochrometer, and is detected by photomultiplier tubes. Each metal atom or ion emits certain characteristic wavelengths of light, which identify whether or not the metal is present in a sample. The concentrations of the metals present are found by aspirating standard solutions with known concentrations. The intensity of light emitted at certain wavelengths is measured at each concentration level. By comparing the intensities of light generated by the sample at certain wavelengths with the intensities generated by the standards, the concentration of the metals in the sample can be found.

The IL ICAP 200 is a sequential reader: it proceeds from the lowest wavelengths to the highest, measuring each programmed wavelength individually. For these analyses, the ICAP was programmed to measure or read each emission line four (4) times, and then continue to the next wavelegth. The four readings were averaged to find the sample's concentration for that metal. For some metals, such as lead and calcium, two emission lines were measured, rather than one. This was used to either double check the analysis or to increase the calibration concentration range. For example, the 393.37 nanometer calcium emission line has a calibration range of 0 to 1.0 ppm, while the 317.93 nanometer emission line has a range up to 50.0 ppm. By measuring both lines, an increased sensitivity is achieved by the 393.37 nm line, while the 317.93 nm line provides a reasonable calibration range. All metal lines were programmed to automatically correct the intensity measurement for background emissions. The vacuum monochrometer was used for all wavelengths below 210 nm. In that range, air becomes a significant interference absorbing much of the wavelength emissions. The vacuum monochrometer eliminates that interference.

At the beginning of each analysis day, the program was recalibrated by measuring the high and low standards. The ICAP automatically readjusts the calibration curves in accordance with the recalibration. A 10 ppm standard was then analyzed to ensure a correct calibration. Any metals calibration having an analysis not within ± 3% of 10 ppm was recalibrated and rechecked until the analysis was within the range of 9.70 ppm to 10.30 ppm. After recalibration, deionized water was analyzed as a background check. Samples were than analyzed. After every high metals concentration sample, deionized water was reanalyzed to ensure that there was no carry-over. The calibration curves were checked every hour by analyzing the 10 ppm standard solution. The response of the torch can change up to 10% hourly due to thermal drift. If necessary, the metals lines were recalibrated and checked before continuing with sample analyses.

After finding the average metals' concentrations in a sample, the known volume of 50 ml was used to find the total micrograms of each metal present. The total micrograms were divided by the original amount of sample weighed into the Parr bombs to give the weight percent of each metal present. Minimum detection limits for the 24 metals analyzed are shown in Table 37.

TABLE 37. MINIMUM DETECTION LIMITS OF THE ICAP

Metal	Detection Limit[a] (ppm)
Al	0.08
Sb	0.07
As	0.08
Ba	0.004
Cd	0.010
Ca	0.007
Cr	0.04
Co	0.01
Cu	0.005
Au	0.04
Fe	0.005
Pb	0.08
Mg	0.003
Mn	0.004
Ni	0.002
P	0.03
Se	0.08
Ag	0.004
Na	0.05
S	0.08
Sn	0.05
Ti	0.009
V	0.010
Zn	0.003

[a] Minimum liquid phase concentration (ug/ml) detectable by the ICAP.

SECTION 6

QUALITY ASSURANCE/QUALITY CONTROL

This section summarizes results of quality assurance and quality control (QA/QC) activities conducted during the baghouse test program. A discussion of problems encountered during the program is included.

FIELD SAMPLING

Field sampling QA/QC activities included equipment calibration, SASS train operational procedure checks and preparation of a SASS train field blank. These activities are briefly summarized below.

Equipment Preparation and Calibration

The SASS sampling trains were inspected and prepared for field use as specified in Section 4. Pretest calibrations or inspections were conducted on pitot tubes, sampling nozzles, temperature sensors, analytical balances, and dry gas meters.

Calibration of the continuous monitoring equipment included a three point (two upscale plus zero) linearity check on on the first test day, single point and zero calibration checks at the beginning of each test day, and single point drift checks at the end of each test day.

SASS Train Operation

The SASS trains were operated to achieve target isokinetics of 100± 20%. The data in Appendix B show that the overall average isokinetics were 121.5 percent at the baghouse inlet location; 104.0 percent at the scrubber outlet location; and 91.8 percent at the baghouse outlet location. One test run in the scrubber test series (Run 01) was repeated because unacceptable isokinetics were obtained at the scrubber outlet location. One test run in the baghouse test series (Run 05) was repeated due to a power supply interruption during sampling. The samples from these test runs were not analyzed for metals content. The sample train leak check criteria of 0.05 cfm was met for all sample runs except for Run 06 at the baghouse outlet location (0.07 cfm leak rate). The sample train volume for that run was corrected accordingly.

SASS Train Field Blank

A SASS train field blank was prepared using glassware that had been used for a previous test run, a filter from the same lot as the test run filters, and nitric acid impinger solution from the same batch as the test runs. The blank train clean-up procedures were identical to those of the test run sample trains. The field blank samples were submitted to the laboratory for metals analysis. The results of the field blank train analysis are discussed in the following section.

Sample Shipment

The sludge feed sample for Run 02 was broken during sample shipment. Therefore, trace metals data are not available for this sample.

LABORATORY ANALYSIS

Laboratory QA/QC activities for the baghouse test program included ICAP calibration procedures. ICAP analysis of NBS Coal Fly Ash Standard 1633A, duplicate ICAP analyses of several samples from the test program, and ICAP analysis of the SASS train field blank samples. These activities are briefly discussed below.

ICAP Calibration Procedures

The initial programming procedures and the daily calibration procedures for the ICAP instrument are discussed in Section 5.2 The daily calibrations required ± 3 percent accuracy for each metal at a solution concentration of 10 ppm per metal.

ICAP Analysis of NBS Coal Fly Ash

As an adjunct to the analyses performed for the test program samples of NBS Coal Fly Ash 1633A were "ashed" at 3 different temperature conditions, acid digested in a Parr bomb, and analyzed by ICAP. The purpose of the investigation was to check the temperature effect of the ashing step on the metals analysis, and to compare the ICAP results to the NBS-certified metals content of the sample. The three different ashing conditions were: (i) no ashing; (ii) ashing at 110°C; and (iii) ashing at 600°C.

The results of this investigation are contained in Appendix D. The metals content data show some variability between samples ashed at 600°C and samples ashed at 110°C. Nickel, selenium, and manganese were not detected by the ICAP although the NBS data indicated that these species were present in the sample. This may be indicative of matrix interference problems for the coal fly ash sample.

Duplicate Analyses

Duplicate ICAP analyses were performed on the eight samples listed in Table 40. These include all sample types that required ashing and/or Parr bombing digestion except for the sample train filters. Duplicate filter analyses could not be run because the entire sample is used in the analytical procedure.

Two types of duplicates were run for sample types that required both ashing and Parr bomb digestion in the analytical scheme (i.e., sludge feed, bottom ash, baghouse dust). For samples listed as "ash duplicates," two

TABLE 38. SAMPLES FOR WHICH DUPLICATE ANALYSES WERE PERFORMED

Sample Identification	Duplicate Type
1. 10 micron cyclone/probe rinse catch, Run 08 (baghouse inlet)	Bomb
2. 3 micron cyclone, catch Run 06 (baghouse inlet)	Bomb
3. Sludge Feed, Run 06	Ash
4. Sludge Feed, Run 08	Bomb
5. Bottom Ash, Run 04	Ash
6. Bottom Ash, Run 03	Bomb
7. Baghouse Dust, Run 07	Ash
8. Baghouse Dust, Run 06	Bomb

identical portions of the raw sample were subjected to the entire analytical work-up outlined in Section 3.0 (i.e., ashing, Parr bomb digestion and ICAP analysis). For samples listed as "bomb duplicates," two identical portions of the ashed sample were subjected to the analytical work-up following the ashing step (i.e., Parr bomb digestion and ICAP analysis.

In general, the data showed ± 10 percent reproducibility between duplicates for each metal. The "bomb" duplicates and the "ash" duplicates showed comparable reproducibility. Average metals content data are presented in this report for the eight samples for which duplicates analyses were performed.

Field Blank Analyses

ICAP analysis of the filter portion of the field blank SASS train is contained in Appendix E.

The data show that the common metals aluminum, calcium, iron, magnesium, and sodium were the most prevalent species in the filter blank. The filter metals analyses for the test runs were blank-corrected by subtracting the filter blank values from the as-measured values. For several metals, the amount detected in the filter blank was high relative to the concentration detected in the filter catch of the sample. For metals which were detected at less than three times the filter blank results, the filter blank affected the resultant concentration for the filter catch by at least 33 percent. The metals affected varied for each run and sampling location. Appendix E contains sample analysis sheets to show as-measured and blank-corrected filter data for Run 02 (inlet and outlet). In this example, aluminum, arsenic, selenium, titanium, calcium, magnesium, chromium, manganese, and cobalt at the inlet were detected at amounts less than three times the filter blank result. At the outlet, aluminum, arsenic, gold, sodium, titanium, calcium, iron, magnesium, nickel, chromium, manganese and cobalt were detected at amounts less than three times the filter blank result.

Since the filter catch provides only a portion of the total sample results, uncertainty in the filter catch concentration may not significantly affect the total concentration for the sample. Only if the filter catch contributed a significant portion of the total concentration could error be significant. Therefore, those metals which were found in the filter catch at greater than 10 percent of the total concentration and which were detected at less than three times the filter blank results were considered to have uncertain results. A list of the affected metals by sample location is presented in Table 39.

The impinger blank was found to be relatively metal-free, with the most prevalent species being arsenic and phosphorus. With the exception of arsenic, field blank correction of the impinger analyses resulted in very little impact on the reported data for the various metals.

TABLE 39. METALS AFFECTED BY HIGH FILTER BLANK RESULTS

Location	Metal
Scrubber Inlet (Runs 2-4)	Sodium, aluminum, lead, chromium, selenium.
Scrubber Outlet	Aluminum, sodium, zinc, calcium, iron, barium, arsenic, titanium, nickel.
Baghouse Inlet (Runs 6-8)	Sodium, aluminum, nickel.
Baghouse Outlet	Aluminum, iron, magnesium, cadmium, titanium, lead, barium, arsenic, copper, gold.

Impinger Contamination

Contamination is suspected for several metals found in the impinger fraction of the sample trains. Analysis of the impinger solutions revealed excessive concentrations of iron, nickel, and chromium. These metals are the major constituents of certain types of stainless steel. Further analysis of the impinger results indicated that the relative concentrations of iron, nickel, and chromium in the impinger solutions for many runs were similar to the relative concentrations of these same metals in type 316 stainless steel, as shown in Table 40. The impinger bubblers are made of type 316 stainless steel and may have been corroded by the 0.1 normal nitric acid impinger solutions. Based on these observations the impinger concentrations for iron, nickel, and chromium are considered erroneously high and are not included in the total concentrations for a sample. The impinger results for chromium, nickel, and iron are included in Appendix A.

Contamination Inferred from Analytical Results

The tabulated data were checked for internal consistency by comparing the concentration of metal in a size fraction catch at the inlet and outlet both for the scrubber and for the baghouse. For a scrubber or a baghouse, the collection of particles in a given fraction is primarily a function of aerodynamic forces. Consequently, the composition of a size fraction would not be expected to change substantially from inlet to outlet, although the quantity collected downstream from the device (the outlet) would be substantially diminished from the quantity collected upstream. All comparisons between inlet and outlet compositions that were examined and those that showed a discrepancy of a factor of about 10^2 or greater were noted. Compositions where one concentration was given as zero are not shown since it could merely be that the quantity of the metal in the catch was below detectable limits. In all, 288 comparisons of inlet to outlet composition were possible. There were 10 incidents where a composition ratio of about 10^2 was observed (in all cases, outlet was higher than inlet). One incident each occurred for cobalt, silver, arsenic, and gold, and 3 incidents each occurred for aluminum and chromium. The compositions observed for aluminum and chromium are shown in Table 41. All of the aluminum incidents occurred for the filter catch (< 1 μm), whereas all of the chromium incidents occurred for the probe wash + 10 μm catch.

Examination of the aluminum incidents shows unmistakable evidence of contamination since all of the outlet concentrations were greater than 10^6 parts per million. the contamination could have existed in all of the filter catches but was evident only for the baghouse runs (Runs 6, 7, 8) because the total mass of the catch was so small. The losses of aluminum then were clearly inflated. No special notice of the discovery was made in the Results section because cautions about excessive concentrations of aluminum in blanks had already been made.

The chromium concentrations in the outlet samples did not exceed 10^6 parts per million, unlike aluminum, so there was no unmistakable evidence of

TABLE 40. RELATIVE CONCENTRATIONS OF IRON, NICKEL, AND CHROMIUM IN TYPE 316 STAINLESS STEEL AND THE IMPINGER SOLUTIONS

Sample	Relative Concentration[a]		
	Iron	Nickel	Chromium
Type 316 Stainless Steel	3.8	0.61	1
Inlet[b]			
Run 2	3.8	0.47	1
Run 3	4.5	0.52	1
Run 4	11	0.57	1
Run 6	4.3	0.51	1
Run 7	4.0	0.51	1
Run 8	3.9	0.68	1
Outlet[b]			
Run 2	9.3	0.74	1
Run 3	3.6	2.7	1
Run 4	5.1	2.1	1
Run 6	5.5	0.46	1
Run 7	5.5	0.24	1
Run 8	12	1.9	1

[a] Relative concentrations calculated by dividing concentration of given metal by the concentrations of chromium.

[b] Runs 2 through 4 for scrubber; Runs 6 through 8 for baghouse.

TABLE 41

Incidents for Chromium and Aluminum Where Ratio of Concentrations at Inlet to Outlet of the Particle Collector Exceeded 10^2

	Chromium Concentration ($\mu g/g$) (Probe + 10 μm Catch		Aluminum Concentration ($\mu g/g$) (Filter Catch)	
Run	Inlet	Outlet	Inlet	Outlet
3 (scrubber)	4.73E2	1.88E4		
6 (baghouse)	3.28E2	2.56E4	2.70E4	2.40E6
7 (baghouse)	5.85E2	2.93E4	3.88E2	4.13E6
8 (baghouse)			2.75E4	5.08E6

an error. A source of contamination was available since the probe tip was constructed of stainless steel and one of the washes was with dilute nitric acid. If contamination occurred during both inlet or outlet runs, its effect would be evident predominantly at the outlet because mass of the catch was small. As noted above, outlet concentrations were higher than inlets for the 3 incidents. In light of evidence pointing toward contamination, it was noted in the Results section (Section 3) that results indicating enrichment of chromium noted for either the scrubber or the baghouse could be in error.

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2. Bennett, R. L. and K. T. Knapp, Environmental Science and Technology, 1982, 16, 831-836. Reproducing Data from Furr, A. K., et. al., Environmental Science and Technology, 1976, 10, 683.

APPENDIX A

RAW METALS DATA

Appendix A contains four tables per test run: a table of raw analytical data for the SASS train catches (ug/g); a table of corresponding gas phase metals concentration (g/dscm, as measured % O_2); a table of fractional metals distributions data; and a table of sludge, bottom ash, and baghouse dust analytical data.

There is evidence that the impingers were contaminated from an extraneous source and for certain of filter catches, the blanks were too high. These problems are addressed in the report by ignoring impinger catches for the affected metals and noting possible effects of high blanks where appropriate in the text and tables. The data in Appendix A contain the impinger results.

APPENDIX A

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TABLE 6.18 (a) TRACE METALS CONTENT OF PARTICULATE MATTER BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION BASIS)
RUN: 6

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL[a]	1	2	3	4	5	TOTAL[a]
METAL	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g
ALUMINUM	1.02E+03	1.16E+03	3.09E+03	2.70E+04	0.00E+00	3.07E+03	2.60E+04	0.00E+00	0.00E+00	2.40E+06	0.00E+00	7.71E+05
ANTIMONY	2.01E+02	2.45E+02	1.60E+02	5.85E+02	0.00E+00	2.42E+02	0.00E+00	0.00E+00	0.00E+00	1.86E+03	0.00E+00	5.83E+02
ARSENIC	7.34E+02	9.08E+02	1.13E+03	5.81E+02	0.00E+00	7.88E+02	1.41E+03	0.00E+00	0.00E+00	8.14E+03	0.00E+00	3.52E+03
BARIUM	7.96E+01	6.85E+01	8.58E+01	6.50E+02	0.00E+00	1.19E+02	1.69E+03	0.00E+00	0.00E+00	4.34E+03	0.00E+00	2.52E+03
CADMIUM	1.49E+03	5.31E+03	1.16E+04	3.48E+04	6.20E-02		7.48E+03	0.00E+00	0.00E+00	1.58E+04	1.09E-01	
CALCIUM	4.66E+04	5.60E+04	6.71E+04	3.10E+04	1.08E-01		1.19E+05	0.00E+00	0.00E+00	0.00E+00	3.77E-01	
CHROMIUM	3.28E+02	4.87E+02	6.58E+02	4.20E+02	3.98E+00		2.56E+04	0.00E+00	0.00E+00	0.00E+00	4.76E-01	
COBALT	3.92E+01	4.41E+01	4.85E+01	5.89E+01	1.27E-01		8.58E+03	0.00E+00	0.00E+00	0.00E+00	2.65E-01	
COPPER	4.19E+03	5.89E+03	7.63E+03	1.19E+04	0.00E+00	5.39E+03	3.52E+03	0.00E+00	0.00E+00	4.89E+03	0.00E+00	3.95E+03
GOLD	8.91E+00	8.64E+00	1.57E+01	1.99E+01	0.00E+00	9.87E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	5.91E+04	6.89E+04	6.98E+04	1.22E+04	1.70E+01		1.29E+05	0.00E+00	0.00E+00	6.04E+04	2.63E+00	
LEAD	1.61E+03	3.56E+03	7.42E+03	3.30E+04	0.00E+00	4.74E+03	3.38E+03	0.00E+00	0.00E+00	2.24E+04	0.00E+00	9.32E+03
MAGNESIUM	2.17E+04	2.59E+04	9.87E+03	6.45E+03	4.80E-02		2.63E+04	0.00E+00	0.00E+00	7.96E+04	2.60E-02	
MANGANESE	3.25E+02	3.98E+02	4.55E+02	1.64E+02	3.50E-01		0.00E+00	0.00E+00	0.00E+00	2.83E+02	8.70E-02	
NICKEL	1.64E+02	3.44E+02	4.94E+02	1.17E+03	2.02E+00		4.23E+03	0.00E+00	0.00E+00	1.37E+03	2.19E-01	
PHOSPHOROUS	5.89E+04	7.18E+04	7.46E+04	1.69E+04	1.41E+00		3.49E+04	0.00E+00	0.00E+00	1.65E+05	3.77E+00	
SELENIUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.14E-01		6.31E+03	0.00E+00	0.00E+00	4.28E+03	0.00E+00	5.68E+03
SILVER	1.14E+01	6.85E+01	2.32E+02	3.67E+02	0.00E+00	6.24E+01	1.11E+03	0.00E+00	0.00E+00	2.48E+02	0.00E+00	8.42E+02
SODIUM	2.92E+03	4.78E+03	9.32E+03	5.25E+03	0.00E+00	3.86E+03	7.77E+03	0.00E+00	0.00E+00	3.98E+04	0.00E+00	1.78E+04
SULFUR	1.22E+04	2.70E+04	3.94E+04	6.43E+04	7.92E+02		6.90E+04	0.00E+00	0.00E+00	7.26E+04	1.14E+03	
TIN	3.40E+02	8.18E+02	1.80E+03	1.36E+04	1.97E-01		0.00E+00	0.00E+00	0.00E+00	4.94E+03	4.05E-01	
TITANIUM	6.56E+03	7.91E+03	7.33E+03	1.64E+03	0.00E+00	6.62E+03	6.31E+03	0.00E+00	0.00E+00	1.17E+04	0.00E+00	8.01E+03
VANADIUM	5.81E+02	5.48E+03	1.72E+03	4.74E+03	3.40E-02		2.00E+03	0.00E+00	0.00E+00	1.35E+03	0.00E+00	1.80E+03
ZINC	5.80E+03	8.42E+03	1.06E+04	1.52E+04	3.90E-02		2.98E+04	0.00E+00	0.00E+00	5.78E+03	8.70E-02	

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5 (see note a)

[a] Totals for each metal concentration in micrograms per gram could be determined only for the dry sample, as follows:

$$\text{Total}_i \text{ (ug/gm)} = \text{total}_i \text{ (gm/dscm)} \times 1\text{E}{+}06 \text{ ug/gm} / \text{total mass (gm dscm)}$$

For Al,

$$\text{Total}_{i=1} = 1.02 \times 10^{-3} \frac{\text{gm}}{\text{dscm}} \times \frac{10^6 \text{ug}}{\text{gm}} \times \frac{1 \text{ dscm}}{3.31 \times 10^{-1} \text{ gm}}$$

Data in gm/dscm is from Table 6.2B. **When there was some of the element in the impinger the TOTAL is left blank.**

TABLE 6.2B (a) TRACE METALS AND TOTAL PARTICULATE CONCENTRATIONS IN FLUE GAS BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION)
RUN: 6

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)						GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)					
ALUMINUM	2.00E-04	1.16E-04	3.34E-05	6.69E-04	0.00E+00	1.02E-03	2.45E-05	0.00E+00	0.00E+00	1.03E-03	0.00E+00	1.06E-03
ANTIMONY	3.94E-05	2.44E-05	1.73E-06	1.45E-05	0.00E+00	8.00E-05	0.00E+00	0.00E+00	0.00E+00	8.01E-07	0.00E+00	8.01E-07
ARSENIC	1.44E-04	9.03E-05	1.22E-05	1.44E-05	0.00E+00	2.61E-04	1.33E-06	0.00E+00	0.00E+00	3.50E-06	0.00E+00	4.83E-06
BARIUM	1.56E-05	6.81E-06	9.26E-07	1.61E-05	0.00E+00	3.95E-05	1.60E-06	0.00E+00	0.00E+00	1.86E-06	0.00E+00	3.46E-06
CADMIUM	2.92E-04	5.28E-04	1.25E-04	8.64E-04	4.83E-06	1.81E-03	7.06E-06	0.00E+00	0.00E+00	6.79E-06	6.88E-06	2.07E-05
CALCIUM	9.12E-03	5.57E-03	7.25E-04	7.69E-04	8.41E-06	1.62E-02	1.12E-04	0.00E+00	0.00E+00	0.00E+00	2.38E-05	1.36E-04
CHROMIUM	6.42E-05	4.84E-05	7.11E-06	1.04E-05	3.10E-04	4.40E-04	2.41E-05	0.00E+00	0.00E+00	0.00E+00	3.00E-05	5.42E-05
COBALT	7.69E-06	4.38E-06	5.24E-07	1.46E-06	9.89E-06	2.39E-05	8.10E-06	0.00E+00	0.00E+00	0.00E+00	1.67E-05	2.48E-05
COPPER	8.22E-04	5.86E-04	8.24E-05	2.94E-04	0.00E+00	1.78E-03	3.32E-06	0.00E+00	0.00E+00	2.10E-06	0.00E+00	5.43E-06
GOLD	1.75E-06	8.59E-07	1.69E-07	4.93E-07	0.00E+00	3.27E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	1.16E-02	6.95E-03	7.43E-04	3.02E-04	1.33E-03	2.08E-02	1.22E-04	0.00E+00	0.00E+00	2.60E-05	1.66E-04	3.14E-04
LEAD	3.15E-04	3.54E-04	8.02E-05	8.19E-04	0.00E+00	1.57E-03	3.19E-06	0.00E+00	0.00E+00	9.62E-06	0.00E+00	1.28E-05
MAGNESIUM	4.26E-03	2.58E-03	1.07E-04	1.60E-04	3.74E-06	7.11E-03	2.49E-05	0.00E+00	0.00E+00	3.42E-05	1.64E-06	6.08E-05
MANGANESE	6.38E-05	3.96E-05	4.91E-06	4.08E-06	2.72E-05	1.40E-04	0.00E+00	0.00E+00	0.00E+00	1.22E-07	5.49E-06	5.61E-06
NICKEL	3.21E-05	3.42E-05	5.34E-06	2.91E-05	1.57E-04	2.58E-04	3.99E-06	0.00E+00	0.00E+00	5.90E-07	1.38E-05	1.84E-05
PHOSPHOROUS	1.15E-02	7.14E-03	8.06E-04	4.19E-04	1.10E-04	2.00E-02	3.30E-05	0.00E+00	0.00E+00	7.09E-05	2.38E-04	3.42E-04
SELENIUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.22E-05	3.22E-05	5.96E-06	0.00E+00	0.00E+00	1.84E-06	0.00E+00	7.80E-06
SILVER	2.23E-06	6.82E-06	2.50E-06	9.09E-06	0.00E+00	2.06E-05	1.05E-06	0.00E+00	0.00E+00	1.07E-07	0.00E+00	1.16E-06
SODIUM	5.72E-04	4.76E-04	1.01E-04	1.30E-04	0.00E+00	1.28E-03	7.34E-06	0.00E+00	0.00E+00	1.71E-05	0.00E+00	2.45E-05
SULFUR	2.39E-03	2.69E-03	4.25E-04	1.59E-03	6.17E-02	6.88E-02	6.52E-05	0.00E+00	0.00E+00	3.12E-05	7.20E-02	7.21E-02
TIN	6.66E-05	8.14E-05	1.95E-05	3.37E-04	1.53E-05	5.20E-04	0.00E+00	0.00E+00	0.00E+00	2.12E-06	2.55E-05	2.77E-05
TITANIUM	1.29E-03	7.87E-04	7.92E-05	4.06E-05	0.00E+00	2.19E-03	5.96E-06	0.00E+00	0.00E+00	5.05E-06	0.00E+00	1.10E-05
VANADIUM	1.14E-04	5.45E-04	1.86E-05	1.17E-04	2.65E-06	7.98E-04	1.89E-06	0.00E+00	0.00E+00	5.78E-07	0.00E+00	2.47E-06
ZINC	1.14E-03	8.38E-04	1.15E-04	3.78E-04	3.04E-06	2.47E-03	2.82E-05	0.00E+00	0.00E+00	2.48E-06	5.49E-06	3.61E-05
Metals[a] (gm/dscm)	4.41E-02	2.94E-02	3.49E-03	6.99E-03	6.37E-02	1.48E-01	4.85E-04	0.00E+00	0.00E+00	1.25E-03	7.25E-02	
Tot.Mass[b] (gm/dscm)	1.96E-01	9.95E-02	1.08E-02	2.48E-02	-	3.31E-01	9.44E-04	0.00E+00	0.00E+00	4.30E-04	-	1.37E-03

FLUE GAS FLOW RATE (dscmm) 2.73E+00

FLUE GAS FLOW RATE (dscmm) 3.54E+00

[a] Total of metals as determined by ICAP analysis (Table 6.1B), total weighed of fraction j, and gas sampled volume:

$$\text{Total Metals } j = \sum_{i=1}^{i=n} \text{metal}_i \text{ (ug/gm)} \times \text{total mass } j \text{ (gm/dscm)} \times 1E\text{-}06 \text{ (g/ug)}$$

For Al,

$$\text{Total Metals}_{j=1} = 1.02 \times 10^{3} \frac{\text{ug}}{\text{gm}} \times 1.96 \times 10^{-1} \frac{\text{gm}}{\text{dscm}} \times 1E\text{-}06 \frac{\text{gm}}{\text{ug}} = 2.00 \times 10^{-4} \frac{\text{gm}}{\text{dscm}}$$

[b] Total mass of each fraction and of total as determined by weighings and gas sampled volumes.

TABLE 6.3B (a) DISTRIBUTION OF TRACE METALS AND TOTAL PARTICULATE BY PARTICULATE SIZE FRACTION (SASS SIZE BASIS)
RUN: 6

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	FRACTION OF METAL i IN SIZE FRACTION j						FRACTION OF METAL i IN SIZE FRACTION j					
ALUMINUM	1.96E-01	1.14E-01	3.28E-02	6.57E-01	0.00E+00	1.00E+00	2.32E-02	0.00E+00	0.00E+00	9.77E-01	0.00E+00	1.00E+00
ANTIMONY	4.93E-01	3.05E-01	2.16E-02	1.81E-01	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
ARSENIC	5.52E-01	3.46E-01	4.69E-02	5.52E-02	0.00E+00	1.00E+00	2.75E-01	0.00E+00	0.00E+00	7.25E-01	0.00E+00	1.00E+00
BARIUM	3.95E-01	1.73E-01	2.35E-02	4.09E-01	0.00E+00	1.00E+00	4.61E-01	0.00E+00	0.00E+00	5.39E-01	0.00E+00	1.00E+00
CADMIUM	1.61E-01	2.91E-01	6.91E-02	4.76E-01	2.66E-03	1.00E+00	3.41E-01	0.00E+00	0.00E+00	3.28E-01	3.32E-01	1.00E+00
CALCIUM	5.63E-01	3.44E-01	4.47E-02	4.75E-02	5.19E-04	1.00E+00	8.25E-01	0.00E+00	0.00E+00	0.00E+00	1.75E-01	1.00E+00
CHROMIUM	1.46E-01	1.10E-01	1.62E-02	2.37E-02	7.04E-01	1.00E+00	4.46E-01	0.00E+00	0.00E+00	0.00E+00	5.54E-01	1.00E+00
COBALT	3.21E-01	1.83E-01	2.19E-02	6.10E-02	4.13E-01	1.00E+00	3.26E-01	0.00E+00	0.00E+00	0.00E+00	6.74E-01	1.00E+00
COPPER	4.61E-01	3.28E-01	4.62E-02	1.65E-01	0.00E+00	1.00E+00	6.13E-01	0.00E+00	0.00E+00	3.87E-01	0.00E+00	1.00E+00
GOLD	5.35E-01	2.63E-01	5.17E-02	1.51E-01	0.00E+00	1.00E+00	ND	ND	ND	ND	ND	ND
IRON	5.57E-01	3.29E-01	3.57E-02	1.45E-02	6.37E-02	1.00E+00	3.88E-01	0.00E+00	0.00E+00	8.28E-02	5.29E-01	1.00E+00
LEAD	2.01E-01	2.26E-01	5.11E-02	5.22E-01	0.00E+00	1.00E+00	2.49E-01	0.00E+00	0.00E+00	7.51E-01	0.00E+00	1.00E+00
MAGNESIUM	5.99E-01	3.63E-01	1.50E-02	2.25E-02	5.26E-04	1.00E+00	4.09E-01	0.00E+00	0.00E+00	5.64E-01	2.70E-02	1.00E+00
MANGANESE	4.57E-01	2.84E-01	3.52E-02	2.92E-02	1.95E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	2.17E-02	9.78E-01	1.00E+00
NICKEL	1.24E-01	1.33E-01	2.07E-02	1.13E-01	6.10E-01	1.00E+00	2.17E-01	0.00E+00	0.00E+00	3.21E-02	7.51E-01	1.00E+00
PHOSPHOROUS	5.76E-01	3.57E-01	4.03E-02	2.10E-02	5.48E-03	1.00E+00	9.65E-02	0.00E+00	0.00E+00	2.08E-01	6.96E-01	1.00E+00
SELENIUM	ND	ND	ND	ND	ND	ND	7.64E-01	0.00E+00	0.00E+00	2.36E-01	0.00E+00	1.00E+00
SILVER	1.08E-01	3.30E-01	1.21E-01	4.40E-01	0.00E+00	1.00E+00	9.08E-01	0.00E+00	0.00E+00	9.21E-02	0.00E+00	1.00E+00
SODIUM	4.47E-01	3.72E-01	7.87E-02	1.02E-01	0.00E+00	1.00E+00	3.00E-01	0.00E+00	0.00E+00	7.00E-01	0.00E+00	1.00E+00
SULFUR	3.47E-02	3.91E-02	6.18E-03	2.32E-02	8.97E-01	1.00E+00	9.04E-04	0.00E+00	0.00E+00	4.33E-04	9.99E-01	1.00E+00
TIN	1.28E-01	1.56E-01	3.74E-02	6.49E-01	2.95E-02	1.00E+00	0.00E+00	0.00E+00	0.00E+00	7.67E-02	9.23E-01	1.00E+00
TITANIUM	5.86E-01	3.59E-01	3.61E-02	1.85E-02	0.00E+00	1.00E+00	5.41E-01	0.00E+00	0.00E+00	4.59E-01	0.00E+00	1.00E+00
VANADIUM	1.43E-01	6.84E-01	2.33E-02	1.47E-01	3.32E-03	1.00E+00	7.65E-01	0.00E+00	0.00E+00	2.35E-01	0.00E+00	1.00E+00
ZINC	4.60E-01	3.39E-01	4.64E-02	1.53E-01	1.23E-03	1.00E+00	7.79E-01	0.00E+00	0.00E+00	6.88E-02	1.52E-01	1.00E+00

FRACTION OF ELEMENT i IN SIZE FRACTION j = MASS OF ELEMENT i IN SASS SIZE FRACTION j
DIVIDED BY TOTAL MASS OF ELEMENT i IN ALL SASS SIZE FRACTIONS

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

TABLE 6.5 TRACE METALS CONTENT OF SLUDGE, BOTTOM ASH AND BAGHOUSE BOTTOM DUST

RUN 6

	FEED SLUDGE	BOTTOM ASH	BAGHOUSE DUST
METAL	PPM	PPM	PPM
ALUMINUM	6.79E+02	1.74E+03	2.94E+03
ANTIMONY	1.98E+02	2.21E+02	1.58E+02
ARSENIC	5.34E+02	6.71E+02	8.20E+02
BARIUM	6.38E+01	7.56E+01	7.95E+01
CADMIUM	1.99E+02	5.82E+01	4.96E+03
CALCIUM	5.03E+04	3.59E+04	5.66E+04
CHROMIUM	3.49E+02	4.50E+02	6.71E+02
COBALT	2.94E+01	3.44E+01	4.53E+01
COPPER	4.08E+03	4.50E+03	4.88E+03
GOLD	3.60E+00	7.02E+00	2.42E+00
IRON	5.25E+04	4.54E+04	6.60E+04
LEAD	6.02E+02	4.64E+02	4.18E+03
MAGNESIUM	1.99E+04	1.08E+04	6.20E+03
MANGANESE	2.37E+02	3.01E+02	3.84E+02
NICKEL	1.18E+02	1.68E+02	3.97E+02
PHOSPHOROUS	5.57E+04	6.75E+04	6.09E+04
SELENIUM	1.73E+01	0.00E+00	1.36E+01
SILVER	2.57E+00	3.08E+01	4.25E+00
SODIUM	3.01E+03	4.32E+03	6.96E+03
SULFUR	2.32E+04	4.38E+03	2.60E+04
TIN	2.67E+02	2.89E+02	1.07E+03
TITANIUM	5.87E+03	6.75E+03	6.15E+03
VANADIUM	3.85E+02	4.24E+02	9.10E+02
ZINC	5.38E+03	5.65E+03	7.99E+03

TABLE 7.1B (a) TRACE METALS CONTENT OF PARTICULATE MATTER BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION BASIS)
RUN: 7

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL[a]	1	2	3	4	5	TOTAL[a]
METAL	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g
ALUMINUM	1.22E+03	9.41E+02	2.69E+04	3.88E+02	0.00E+00	2.32E+03	1.17E+04	0.00E+00	0.00E+00	4.13E+06	0.00E+00	6.56E+05
ANTIMONY	2.43E+02	2.59E+02	1.44E+02	5.19E+02	0.00E+00	2.62E+02	2.94E+03	0.00E+00	0.00E+00	9.25E+02	0.00E+00	2.62E+03
ARSENIC	7.85E+02	9.18E+02	9.48E+02	5.15E+02	0.00E+00	8.17E+02	1.47E+03	0.00E+00	0.00E+00	1.10E+04	0.00E+00	2.97E+03
BARIUM	7.64E+01	7.18E+01	5.61E+02	2.10E+03	0.00E+00	2.38E+02	6.34E+02	0.00E+00	0.00E+00	1.28E+04	0.00E+00	2.54E+03
CADMIUM	1.64E+03	6.29E+03	1.21E+04	2.81E+04	7.40E-02		1.85E+04	0.00E+00	0.00E+00	1.20E+04	0.00E+00	1.75E+04
CALCIUM	2.49E+04	6.65E+04	7.42E+04	5.39E+04	1.59E-01		1.09E+05	0.00E+00	0.00E+00	0.00E+00	2.03E-01	
CHROMIUM	5.85E+02	6.22E+02	5.52E+02	3.39E+02	1.78E+01		2.93E+04	0.00E+00	0.00E+00	0.00E+00	5.49E-01	
COBALT	4.54E+01	4.84E+01	5.72E+01	3.25E+01	3.50E-01		0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-02	
COPPER	4.25E+03	6.72E+03	8.25E+03	9.13E+03	6.50E-02		1.58E+03	0.00E+00	0.00E+00	2.02E+03	0.00E+00	1.65E+03
GOLD	6.85E+00	1.03E+01	1.18E+01	1.73E+01	0.00E+00	8.91E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	4.98E+04	9.31E+04	8.96E+04	9.35E+03	7.05E+01		1.36E+05	0.00E+00	0.00E+00	9.29E+04	3.04E+00	
LEAD	1.42E+03	3.43E+03	8.65E+03	2.81E+04	0.00E+00	4.25E+03	0.00E+00	0.00E+00	0.00E+00	2.10E+04	0.00E+00	3.29E+03
MAGNESIUM	1.12E+04	2.54E+04	2.75E+04	0.00E+00	5.00E-02		2.56E+04	0.00E+00	0.00E+00	3.08E+04	3.10E-02	
MANGANESE	3.96E+02	4.59E+02	5.36E+02	9.63E+01	1.77E+00		4.91E+02	0.00E+00	0.00E+00	4.11E+01	1.01E-01	
NICKEL	3.14E+02	4.30E+02	5.49E+02	3.68E+02	9.04E+00		1.38E+04	0.00E+00	0.00E+00	2.47E+03	1.29E-01	
PHOSPHOROUS	6.73E+03	7.39E+04	7.79E+04	1.30E+04	3.05E+00		3.82E+04	0.00E+00	0.00E+00	0.00E+00	1.91E+00	
SELENIUM	0.00E+00	0.00E+00	0.00E+00	3.54E+01	2.57E+00		6.72E+03	0.00E+00	0.00E+00	0.00E+00	3.63E+00	
SILVER	1.58E+01	4.40E+01	1.22E+01	3.27E+01	0.00E+00	2.58E+01	3.69E+02	0.00E+00	0.00E+00	8.22E+02	0.00E+00	4.39E+02
SODIUM	3.42E+03	3.89E+03	9.60E+03	1.27E+04	0.00E+00	4.51E+03	7.48E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.31E+03
SULFUR	1.09E+04	2.60E+04	4.00E+04	5.38E+04	9.38E+02		1.51E+05	0.00E+00	0.00E+00	6.16E+04	8.57E+02	
TIN	3.93E+02	8.92E+02	1.58E+03	1.13E+04	0.00E+00	1.36E+03	0.00E+00	0.00E+00	0.00E+00	1.52E+03	4.00E-01	
TITANIUM	7.34E+03	8.90E+03	8.38E+03	1.52E+03	0.00E+00	7.48E+03	1.94E+03	0.00E+00	0.00E+00	1.78E+04	0.00E+00	4.42E+03
VANADIUM	6.27E+02	8.52E+02	1.35E+03	2.37E+03	1.25E-01		3.37E+03	0.00E+00	0.00E+00	3.84E+02	0.00E+00	2.90E+03
ZINC	6.33E+03	1.00E+04	1.23E+04	1.13E+04	6.40E-02		7.17E+04	0.00E+00	0.00E+00	4.02E+03	3.70E-02	

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

[a] See note a in Table 6.1B.

TABLE 7.2B (a) TRACE METALS AND TOTAL PARTICULATE CONCENTRATIONS IN FLUE GAS BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION)
RUN: 7

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)						GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)					
ALUMINUM	2.54E-04	1.11E-04	4.82E-04	9.88E-06	0.00E+00	8.57E-04	1.57E-05	0.00E+00	0.00E+00	1.03E-03	0.00E+00	1.05E-03
ANTIMONY	5.05E-05	3.04E-05	2.57E-06	1.32E-05	0.00E+00	9.67E-05	3.96E-06	0.00E+00	0.00E+00	2.31E-07	0.00E+00	4.20E-06
ARSENIC	1.63E-04	1.08E-04	1.70E-05	1.31E-05	0.00E+00	3.01E-04	1.99E-06	0.00E+00	0.00E+00	2.76E-06	0.00E+00	4.75E-06
BARIUM	1.59E-05	8.44E-06	1.00E-05	5.35E-05	0.00E+00	8.79E-05	8.56E-07	0.00E+00	0.00E+00	3.21E-06	0.00E+00	4.06E-06
CADMIUM	3.41E-04	7.39E-04	2.17E-04	7.15E-04	4.02E-06	2.02E-03	2.50E-05	0.00E+00	0.00E+00	3.01E-06	0.00E+00	2.80E-05
CALCIUM	5.18E-03	7.82E-03	1.33E-03	1.37E-03	8.64E-06	1.57E-02	1.47E-04	0.00E+00	0.00E+00	0.00E+00	1.64E-05	1.63E-04
CHROMIUM	1.22E-04	7.32E-05	9.88E-06	8.63E-06	9.70E-04	1.18E-03	3.96E-05	0.00E+00	0.00E+00	0.00E+00	4.43E-05	8.39E-05
COBALT	9.44E-06	5.69E-06	1.02E-06	8.29E-07	1.90E-05	3.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.79E-06	3.79E-06
COPPER	8.34E-04	7.90E-04	1.48E-04	2.33E-04	3.53E-06	2.06E-03	2.14E-06	0.00E+00	0.00E+00	5.05E-07	0.00E+00	2.64E-06
GOLD	1.42E-06	1.21E-06	2.11E-07	4.40E-07	0.00E+00	3.29E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	1.03E-02	9.77E-03	1.60E-03	2.13E-04	3.83E-03	2.58E-02	1.84E-04	0.00E+00	0.00E+00	2.32E-05	2.45E-04	4.52E-04
LEAD	2.95E-04	4.03E-04	1.55E-04	7.17E-04	0.00E+00	1.57E-03	0.00E+00	0.00E+00	0.00E+00	5.26E-06	0.00E+00	5.26E-06
MAGNESIUM	2.34E-03	2.99E-03	4.92E-04	0.00E+00	2.72E-06	5.82E-03	3.46E-05	0.00E+00	0.00E+00	7.71E-06	2.50E-06	4.48E-05
MANGANESE	8.23E-05	5.40E-05	9.59E-06	2.46E-06	9.62E-05	2.44E-04	6.63E-07	0.00E+00	0.00E+00	1.03E-08	8.15E-06	8.82E-06
NICKEL	6.53E-05	5.06E-05	9.82E-06	9.38E-06	4.91E-04	6.27E-04	1.86E-05	0.00E+00	0.00E+00	6.17E-07	1.04E-05	2.96E-05
PHOSPHOROUS	1.40E-03	8.69E-03	1.39E-03	3.31E-04	1.66E-04	1.20E-02	5.16E-05	0.00E+00	0.00E+00	0.00E+00	1.54E-04	2.06E-04
SELENIUM	0.00E+00	0.00E+00	0.00E+00	9.04E-07	1.40E-04	1.41E-04	9.07E-06	0.00E+00	0.00E+00	0.00E+00	2.93E-04	3.02E-04
SILVER	3.29E-06	5.17E-06	2.19E-07	8.35E-07	0.00E+00	9.52E-06	4.98E-07	0.00E+00	0.00E+00	2.06E-07	0.00E+00	7.03E-07
SODIUM	7.11E-04	4.58E-04	1.72E-04	3.24E-04	0.00E+00	1.66E-03	1.01E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-05
SULFUR	2.27E-03	3.06E-03	7.16E-04	1.37E-03	5.10E-02	5.84E-02	2.04E-04	0.00E+00	0.00E+00	1.54E-05	6.91E-02	6.93E-02
TIN	8.18E-05	1.05E-04	2.83E-05	2.88E-04	0.00E+00	5.03E-04	0.00E+00	0.00E+00	0.00E+00	3.80E-07	3.23E-05	3.26E-05
TITANIUM	1.53E-03	1.05E-03	1.50E-04	3.87E-05	0.00E+00	2.76E-03	2.62E-06	0.00E+00	0.00E+00	4.45E-06	0.00E+00	7.07E-06
VANADIUM	1.30E-04	1.00E-04	2.41E-05	6.05E-05	6.80E-06	3.22E-04	4.54E-06	0.00E+00	0.00E+00	9.59E-08	0.00E+00	4.64E-06
ZINC	1.32E-03	1.18E-03	2.19E-04	2.89E-04	3.48E-06	3.01E-03	9.69E-05	0.00E+00	0.00E+00	1.01E-06	2.98E-06	1.01E-04
Metals[a] (gm/dscm)	2.76E-02	3.76E-02	7.19E-03	6.07E-03	5.67E-02	1.35E-01	8.53E-04	0.00E+00	0.00E+00	1.10E-03	6.99E-02	
Tot.Mass[a] (gm/dscm)	2.08E-01	1.18E-01	1.79E-02	2.55E-02	-	3.69E-01	1.35E-03	0.00E+00	0.00E+00	2.50E-04	-	1.60E-03

FLUE GAS FLOW RATE (dscmm)	2.83E+00	FLUE GAS FLOW RATE (dscmm)	3.60E+00

[a] See notes a and b in Table 6.2B.

TABLE 7.3B (a) DISTRIBUTION OF TRACE METALS AND TOTAL PARTICULATE BY PARTICULATE SIZE FRACTION (SASS SIZE BASIS)
RUN: 7

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	FRACTION OF METAL i IN SIZE FRACTION j						FRACTION OF METAL i IN SIZE FRACTION j					
ALUMINUM	2.97E-01	1.29E-01	5.63E-01	1.15E-02	0.00E+00	1.00E+00	1.50E-02	0.00E+00	0.00E+00	9.85E-01	0.00E+00	1.00E+00
ANTIMONY	5.22E-01	3.15E-01	2.66E-02	1.37E-01	0.00E+00	1.00E+00	9.45E-01	0.00E+00	0.00E+00	5.51E-02	0.00E+00	1.00E+00
ARSENIC	5.42E-01	3.58E-01	5.63E-02	4.35E-02	0.00E+00	1.00E+00	4.19E-01	0.00E+00	0.00E+00	5.81E-01	0.00E+00	1.00E+00
BARIUM	1.81E-01	9.61E-02	1.14E-01	6.09E-01	0.00E+00	1.00E+00	2.11E-01	0.00E+00	0.00E+00	7.89E-01	0.00E+00	1.00E+00
CADMIUM	1.69E-01	3.67E-01	1.08E-01	3.55E-01	2.00E-03	1.00E+00	8.93E-01	0.00E+00	0.00E+00	1.07E-01	0.00E+00	1.00E+00
CALCIUM	3.30E-01	4.97E-01	8.46E-02	8.75E-02	5.50E-04	1.00E+00	9.00E-01	0.00E+00	0.00E+00	0.00E+00	1.00E-01	1.00E+00
CHROMIUM	1.03E-01	6.18E-02	8.35E-03	7.30E-03	8.20E-01	1.00E+00	4.72E-01	0.00E+00	0.00E+00	0.00E+00	5.28E-01	1.00E+00
COBALT	2.62E-01	1.58E-01	2.84E-02	2.30E-02	5.28E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00
COPPER	4.29E-01	3.84E-01	7.17E-02	1.13E-01	1.72E-03	1.00E+00	8.09E-01	0.00E+00	0.00E+00	1.91E-01	0.00E+00	1.00E+00
GOLD	4.33E-01	3.68E-01	6.43E-02	1.34E-01	0.00E+00	1.00E+00	ND	ND	ND	ND	ND	ND
IRON	4.02E-01	3.79E-01	6.22E-02	8.27E-03	1.49E-01	1.00E+00	4.07E-01	0.00E+00	0.00E+00	5.13E-02	5.42E-01	1.00E+00
LEAD	1.88E-01	2.57E-01	9.86E-02	4.57E-01	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
MAGNESIUM	4.01E-01	5.14E-01	8.45E-02	0.00E+00	4.67E-04	1.00E+00	7.72E-01	0.00E+00	0.00E+00	1.72E-01	5.58E-02	1.00E+00
MANGANESE	3.36E-01	2.21E-01	3.92E-02	1.00E-02	3.94E-01	1.00E+00	7.52E-02	0.00E+00	0.00E+00	1.17E-03	9.24E-01	1.00E+00
NICKEL	1.04E-01	8.08E-02	1.57E-02	1.50E-02	7.84E-01	1.00E+00	6.28E-01	0.00E+00	0.00E+00	2.08E-02	3.52E-01	1.00E+00
PHOSPHOROUS	1.17E-01	7.25E-01	1.16E-01	2.76E-02	1.38E-02	1.00E+00	2.51E-01	0.00E+00	0.00E+00	0.00E+00	7.49E-01	1.00E+00
SELENIUM	ND	ND	ND	ND	ND	ND	3.01E-02	0.00E+00	0.00E+00	0.00E+00	9.70E-01	1.00E+00
SILVER	3.46E-01	5.43E-01	2.30E-02	8.77E-02	0.00E+00	1.00E+00	7.08E-01	0.00E+00	0.00E+00	2.92E-01	0.00E+00	1.00E+00
SODIUM	4.27E-01	2.75E-01	1.03E-01	1.95E-01	0.00E+00	1.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
SULFUR	3.89E-02	5.24E-02	1.23E-02	2.35E-02	8.73E-01	1.00E+00	2.94E-03	0.00E+00	0.00E+00	2.22E-04	9.97E-01	1.00E+00
TIN	1.63E-01	2.09E-01	5.62E-02	5.72E-01	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-02	9.88E-01	1.00E+00
TITANIUM	5.53E-01	3.79E-01	5.43E-02	1.40E-02	0.00E+00	1.00E+00	3.71E-01	0.00E+00	0.00E+00	6.29E-01	0.00E+00	1.00E+00
VANADIUM	4.05E-01	3.11E-01	7.50E-02	1.88E-01	2.11E-02	1.00E+00	9.79E-01	0.00E+00	0.00E+00	2.07E-02	0.00E+00	1.00E+00
ZINC	4.38E-01	3.92E-01	7.29E-02	9.61E-02	1.16E-03	1.00E+00	9.60E-01	0.00E+00	0.00E+00	9.97E-03	2.96E-02	1.00E+00

FRACTION OF ELEMENT i IN SIZE FRACTION j = MASS OF ELEMENT i IN SASS SIZE FRACTION j
DIVIDED BY TOTAL MASS OF ELEMENT i IN ALL SASS SIZE FRACTIONS

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

TABLE 7.5 TRACE METALS CONTENT OF SLUDGE, BOTTOM ASH AND BAGHOUSE BOTTOM DUST

RUN 7

	FEED SLUDGE	BOTTOM ASH	BAGHOUSE DUST
METAL	PPM	PPM	PPM
ALUMINUM	2.39E+03	7.78E+02	1.48E+03
ANTIMONY	2.24E+02	2.16E+02	2.13E+02
ARSENIC	5.80E+02	6.07E+02	7.62E+02
BARIUM	8.80E+01	9.29E+01	5.82E+01
CADMIUM	2.38E+02	6.00E+01	4.10E+03
CALCIUM	1.72E+04	3.07E+04	3.92E+04
CHROMIUM	3.71E+02	4.16E+02	5.53E+02
COBALT	3.98E+01	3.26E+01	4.35E+01
COPPER	4.87E+03	4.23E+03	5.10E+03
GOLD	3.53E+00	2.32E+00	2.68E+00
IRON	5.33E+04	4.26E+04	6.28E+04
LEAD	7.79E+02	4.34E+02	1.54E+03
MAGNESIUM	8.32E+03	1.05E+04	1.45E+04
MANGANESE	3.17E+02	2.92E+02	3.77E+02
NICKEL	1.56E+02	1.37E+02	3.38E+02
PHOSPHOROUS	6.46E+04	6.27E+04	5.97E+04
SELENIUM	0.00E+00	0.00E+00	6.56E+01
SILVER	1.39E+01	1.48E+01	1.60E+00
SODIUM	3.43E+03	3.61E+03	2.79E+03
SULFUR	2.62E+04	6.03E+03	2.26E+04
TIN	3.08E+02	2.37E+02	8.45E+02
TITANIUM	6.94E+03	6.20E+03	6.81E+03
VANADIUM	4.63E+02	3.63E+02	7.47E+02
ZINC	6.58E+03	5.53E+03	7.22E+03

TABLE 9.1B (a) TRACE METALS CONTENT OF PARTICULATE MATTER BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION BASIS)
RUN: 8

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL[a]	1	2	3	4	5	TOTAL[a]
METAL	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g
ALUMINUM	1.07E+03	1.63E+03	1.50E+03	2.75E+04	0.00E+00	3.54E+03	7.24E+02	0.00E+00	0.00E+00	5.09E+06	0.00E+00	1.58E+05
ANTIMONY	2.50E+02	8.09E+01	1.27E+02	3.78E+02	0.00E+00	2.06E+02	3.03E+02	0.00E+00	0.00E+00	1.49E+03	1.18E-01	2.22E+03
ARSENIC	8.07E+02	9.43E+02	1.09E+03	5.40E+02	0.00E+00	8.38E+02	0.00E+00	0.00E+00	0.00E+00	2.33E+04	0.00E+00	7.22E+02
BARIUM	1.03E+02	9.89E+01	7.94E+01	2.18E+03	0.00E+00	2.81E+02	3.94E+01	0.00E+00	0.00E+00	6.63E+04	0.00E+00	2.09E+03
CADMIUM	1.63E+03	4.45E+03	9.08E+03	2.00E+04	2.10E-01		3.31E+03	0.00E+00	0.00E+00	2.30E+03	0.00E+00	3.28E+03
CALCIUM	6.44E+04	7.30E+04	6.10E+04	4.32E+04	5.56E-01		5.83E+03	0.00E+00	0.00E+00	0.00E+00	2.07E-01	
CHROMIUM	4.29E+02	4.46E+02	5.55E+02	3.43E+02	9.55E-01		7.20E+02	0.00E+00	0.00E+00	0.00E+00	2.89E-01	
COBALT	4.16E+01	4.27E+01	4.70E+01	5.66E+01	2.94E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
COPPER	4.50E+03	6.08E+03	8.20E+03	7.81E+03	1.73E-01		1.09E+02	0.00E+00	0.00E+00	1.15E+03	0.00E+00	1.42E+02
GOLD	4.09E+00	6.11E+00	1.17E+01	1.50E+01	0.00E+00	6.02E+00	0.00E+00	0.00E+00	0.00E+00	1.01E+03	0.00E+00	3.13E+01
IRON	7.53E+04	7.52E+04	7.86E+04	1.32E+04	3.71E+00		3.42E+03	0.00E+00	0.00E+00	2.64E+05	1.91E+00	
LEAD	1.13E+03	2.70E+03	5.61E+03	1.74E+04	0.00E+00	3.23E+03	1.15E+02	0.00E+00	0.00E+00	2.13E+04	0.00E+00	7.69E+02
MAGNESIUM	2.04E+04	2.70E+04	2.39E+04	1.05E+04	1.12E-01		2.85E+03	0.00E+00	0.00E+00	0.00E+00	3.00E-02	
MANGANESE	3.73E+02	4.28E+02	4.43E+02	1.42E+02	1.51E-01		2.37E+01	0.00E+00	0.00E+00	5.48E+02	6.20E-02	
NICKEL	2.02E+02	2.37E+02	3.79E+02	9.43E+02	6.47E-01		0.00E+00	0.00E+00	0.00E+00	3.57E+03	1.55E-01	
PHOSPHORDUS	6.95E+04	7.73E+04	7.82E+04	1.32E+04	6.34E+00		1.81E+03	0.00E+00	0.00E+00	0.00E+00	4.52E+00	
SELENIUM	0.00E+00	0.00E+00	0.00E+00	1.62E+02	0.00E+00	1.40E+01	9.45E+02	0.00E+00	0.00E+00	0.00E+00	2.74E+00	
SILVER	1.45E+01	2.29E+02	4.34E+02	1.44E+01	0.00E+00	9.92E+01	1.79E+01	0.00E+00	0.00E+00	2.86E+02	0.00E+00	2.62E+01
SODIUM	4.20E+03	9.00E+03	8.13E+03	2.62E+04	7.28E-01		1.56E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E+03
SULFUR	9.93E+03	1.80E+04	2.96E+04	4.26E+04	1.49E+03		2.22E+04	0.00E+00	0.00E+00	9.14E+04	1.58E+03	
TIN	3.38E+02	7.26E+02	1.36E+03	5.91E+03	2.40E-01		0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.40E-02	
TITANIUM	7.81E+03	7.75E+03	7.56E+03	1.97E+03	0.00E+00	7.27E+03	1.16E+02	0.00E+00	0.00E+00	4.98E+04	0.00E+00	1.65E+03
VANADIUM	5.47E+02	7.53E+02	9.89E+02	1.81E+03	0.00E+00	7.38E+02	3.04E+02	0.00E+00	0.00E+00	2.98E+02	0.00E+00	3.04E+02
ZINC	7.08E+03	8.53E+03	1.01E+04	8.23E+03	1.60E-01		8.07E+03	0.00E+00	0.00E+00	1.22E+04	7.20E-02	

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

[a] See note a in Table 6.1B.

TABLE 8.2B (a) TRACE METALS AND TOTAL PARTICULATE CONCENTRATIONS IN FLUE GAS BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION)
RUN: 8

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)						GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)					
ALUMINUM	2.35E-04	1.81E-04	3.00E-05	9.15E-04	0.00E+00	1.36E-03	3.29E-06	0.00E+00	0.00E+00	7.37E-04	0.00E+00	7.40E-04
ANTIMONY	5.51E-05	8.96E-06	2.54E-06	1.26E-05	0.00E+00	7.92E-05	1.38E-06	0.00E+00	0.00E+00	2.16E-07	8.82E-06	1.04E-05
ARSENIC	1.78E-04	1.04E-04	2.18E-05	1.80E-05	0.00E+00	3.22E-04	0.00E+00	0.00E+00	0.00E+00	3.38E-06	0.00E+00	3.38E-06
BARIUM	2.27E-05	1.10E-05	1.59E-06	7.26E-05	0.00E+00	1.08E-04	1.79E-07	0.00E+00	0.00E+00	9.61E-06	0.00E+00	9.79E-06
CADMIUM	3.59E-04	4.93E-04	1.82E-04	6.65E-04	1.56E-05	1.72E-03	1.50E-05	0.00E+00	0.00E+00	3.33E-07	0.00E+00	1.54E-05
CALCIUM	1.42E-02	8.09E-03	1.22E-03	1.44E-03	4.14E-05	2.50E-02	2.64E-05	0.00E+00	0.00E+00	0.00E+00	1.55E-05	4.19E-05
CHROMIUM	9.45E-05	4.94E-05	1.11E-05	1.14E-05	7.11E-05	2.38E-04	3.27E-06	0.00E+00	0.00E+00	0.00E+00	2.16E-05	2.49E-05
COBALT	9.15E-06	4.69E-06	9.40E-07	1.89E-06	2.19E-04	2.35E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
COPPER	9.90E-04	6.73E-04	1.64E-04	2.60E-04	1.29E-05	2.10E-03	4.97E-07	0.00E+00	0.00E+00	1.67E-07	0.00E+00	6.64E-07
GOLD	9.01E-07	6.77E-07	2.35E-07	4.99E-07	0.00E+00	2.31E-06	0.00E+00	0.00E+00	0.00E+00	1.47E-07	0.00E+00	1.47E-07
IRON	1.66E-02	8.33E-03	1.57E-03	4.40E-04	2.76E-04	2.72E-02	1.55E-05	0.00E+00	0.00E+00	3.83E-05	1.43E-04	1.97E-04
LEAD	2.50E-04	2.99E-04	1.12E-04	5.80E-04	0.00E+00	1.24E-03	5.23E-07	0.00E+00	0.00E+00	3.08E-06	0.00E+00	3.60E-06
MAGNESIUM	4.48E-03	2.99E-03	4.78E-04	3.49E-04	8.33E-06	8.31E-03	1.29E-05	0.00E+00	0.00E+00	0.00E+00	2.24E-06	1.52E-05
MANGANESE	8.21E-05	4.75E-05	8.86E-06	4.73E-06	1.12E-05	1.54E-04	1.07E-07	0.00E+00	0.00E+00	7.94E-08	4.63E-06	4.82E-06
NICKEL	4.44E-05	2.62E-05	7.58E-06	3.14E-05	4.81E-05	1.58E-04	0.00E+00	0.00E+00	0.00E+00	5.18E-07	1.16E-05	1.21E-05
PHOSPHOROUS	1.53E-02	8.57E-03	1.56E-03	4.41E-04	4.72E-04	2.63E-02	8.22E-06	0.00E+00	0.00E+00	0.00E+00	3.38E-04	3.46E-04
SELENIUM	0.00E+00	0.00E+00	0.00E+00	5.38E-06	0.00E+00	5.38E-06	4.29E-06	0.00E+00	0.00E+00	0.00E+00	2.05E-04	2.09E-04
SILVER	3.19E-06	2.54E-05	8.68E-06	4.78E-07	0.00E+00	3.77E-05	8.13E-08	0.00E+00	0.00E+00	4.14E-08	0.00E+00	1.23E-07
SODIUM	9.24E-04	9.97E-04	1.63E-04	8.73E-04	5.42E-05	3.01E-03	7.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E-06
SULFUR	2.19E-03	1.99E-03	5.91E-04	1.42E-03	1.11E-01	1.17E-01	1.01E-04	0.00E+00	0.00E+00	1.33E-05	1.18E-01	1.18E-01
TIN	7.44E-05	8.04E-05	2.72E-05	1.97E-04	1.79E-05	3.97E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.28E-06	6.28E-06
TITANIUM	1.72E-03	8.59E-04	1.51E-04	6.55E-05	0.00E+00	2.79E-03	5.26E-07	0.00E+00	0.00E+00	7.21E-06	0.00E+00	7.74E-06
VANADIUM	1.20E-04	8.34E-05	1.98E-05	6.01E-05	0.00E+00	2.84E-04	1.38E-06	0.00E+00	0.00E+00	4.32E-08	0.00E+00	1.42E-06
ZINC	1.56E-03	9.45E-04	2.01E-04	2.74E-04	1.19E-05	2.99E-03	3.66E-05	0.00E+00	0.00E+00	1.77E-06	5.38E-06	4.38E-05
Metals[a] (gm/dscm)	5.94E-02	3.49E-02	6.54E-03	8.14E-03	1.12E-01	2.21E-01	2.38E-04	0.00E+00	0.00E+00	8.15E-04	1.19E-01	
Tot.Mass[a] (gm/dscm)	2.20E-01	1.11E-01	2.00E-02	3.33E-02	-	3.84E-01	4.54E-03	0.00E+00	0.00E+00	1.45E-04	-	4.69E-03

FLUE GAS FLOW RATE (dscmm)	2.78E+00	FLUE GAS FLOW RATE (dscmm)	3.60E+00

[a]See notes a and b in Table 6.2B.

TABLE 8.3B (a) DISTRIBUTION OF TRACE METALS AND TOTAL PARTICULATE BY PARTICULATE SIZE FRACTION (SASS SIZE BASIS)
RUN: 8

	BAGHOUSE INLET SASS SIZE FRACTIONS						BAGHOUSE OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	FRACTION OF METAL i IN SIZE FRACTION j						FRACTION OF METAL i IN SIZE FRACTION j					
ALUMINUM	1.73E-01	1.33E-01	2.21E-02	6.72E-01	0.00E+00	1.00E+00	4.44E-03	0.00E+00	0.00E+00	9.96E-01	0.00E+00	1.00E+00
ANTIMONY	6.96E-01	1.13E-01	3.21E-02	1.59E-01	0.00E+00	1.00E+00	1.32E-01	0.00E+00	0.00E+00	2.07E-02	8.47E-01	1.00E+00
ARSENIC	5.52E-01	3.25E-01	6.79E-02	5.59E-02	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
BARIUM	2.10E-01	1.02E-01	1.47E-02	6.73E-01	0.00E+00	1.00E+00	1.83E-02	0.00E+00	0.00E+00	9.82E-01	0.00E+00	1.00E+00
CADMIUM	2.09E-01	2.88E-01	1.06E-01	3.88E-01	9.11E-03	1.00E+00	9.78E-01	0.00E+00	0.00E+00	2.17E-02	0.00E+00	1.00E+00
CALCIUM	5.68E-01	3.24E-01	4.89E-02	5.76E-02	1.66E-03	1.00E+00	6.31E-01	0.00E+00	0.00E+00	0.00E+00	3.69E-01	1.00E+00
CHROMIUM	3.98E-01	2.08E-01	4.68E-02	4.81E-02	2.99E-01	1.00E+00	1.32E-01	0.00E+00	0.00E+00	0.00E+00	8.68E-01	1.00E+00
COBALT	3.89E-02	1.99E-02	3.99E-03	8.01E-03	9.29E-01	1.00E+00	ND	ND	ND	ND	ND	ND
COPPER	4.71E-01	3.21E-01	7.81E-02	1.24E-01	6.13E-03	1.00E+00	7.48E-01	0.00E+00	0.00E+00	2.52E-01	0.00E+00	1.00E+00
GOLD	3.90E-01	2.93E-01	1.02E-01	2.16E-01	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
IRON	6.09E-01	3.06E-01	5.78E-02	1.62E-02	1.02E-02	1.00E+00	7.91E-02	0.00E+00	0.00E+00	1.95E-01	7.26E-01	1.00E+00
LEAD	2.01E-01	2.41E-01	9.04E-02	4.67E-01	0.00E+00	1.00E+00	1.45E-01	0.00E+00	0.00E+00	8.55E-01	0.00E+00	1.00E+00
MAGNESIUM	5.39E-01	3.60E-01	5.76E-02	4.20E-02	1.00E-03	1.00E+00	8.52E-01	0.00E+00	0.00E+00	0.00E+00	1.48E-01	1.00E+00
MANGANESE	5.32E-01	3.07E-01	5.74E-02	3.07E-02	7.28E-02	1.00E+00	2.23E-02	0.00E+00	0.00E+00	1.65E-02	9.61E-01	1.00E+00
NICKEL	2.81E-01	1.66E-01	4.80E-02	1.99E-01	3.05E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	4.28E-02	9.57E-01	1.00E+00
PHOSPHOROUS	5.81E-01	3.25E-01	5.94E-02	1.67E-02	1.79E-02	1.00E+00	2.38E-02	0.00E+00	0.00E+00	0.00E+00	9.76E-01	1.00E+00
SELENIUM	ND	ND	ND	ND	ND	ND	2.05E-02	0.00E+00	0.00E+00	0.00E+00	9.79E-01	1.00E+00
SILVER	8.46E-02	6.73E-01	2.30E-01	1.27E-02	0.00E+00	1.00E+00	6.62E-01	0.00E+00	0.00E+00	3.38E-01	0.00E+00	1.00E+00
SODIUM	3.07E-01	3.31E-01	5.40E-02	2.90E-01	1.80E-02	1.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
SULFUR	1.86E-02	1.70E-02	5.04E-03	1.21E-02	9.47E-01	1.00E+00	8.52E-04	0.00E+00	0.00E+00	1.12E-04	9.99E-01	1.00E+00
TIN	1.88E-01	2.03E-01	6.85E-02	4.96E-01	4.50E-02	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00
TITANIUM	6.15E-01	3.07E-01	5.41E-02	2.34E-02	0.00E+00	1.00E+00	6.79E-02	0.00E+00	0.00E+00	9.32E-01	0.00E+00	1.00E+00
VANADIUM	4.24E-01	2.94E-01	6.97E-02	2.12E-01	0.00E+00	1.00E+00	9.70E-01	0.00E+00	0.00E+00	3.03E-02	0.00E+00	1.00E+00
ZINC	5.21E-01	3.16E-01	6.74E-02	9.17E-02	3.98E-03	1.00E+00	8.37E-01	0.00E+00	0.00E+00	4.05E-02	1.23E-01	1.00E+00

FRACTION OF ELEMENT i IN SIZE FRACTION j = MASS OF ELEMENT i IN SASS SIZE FRACTION j
DIVIDED BY TOTAL MASS OF ELEMENT i IN ALL SASS SIZE FRACTIONS

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

TABLE 8.5 TRACE METALS CONTENT OF SLUDGE, BOTTOM ASH AND BAGHOUSE BOTTOM DUST

RUN 8

	FEED SLUDGE	BOTTOM ASH	BAGHOUSE DUST
METAL	PPM	PPM	PPM
ALUMINUM	1.17E+03	1.24E+03	5.03E+03
ANTIMONY	2.20E+02	2.20E+02	2.47E+02
ARSENIC	5.98E+02	7.07E+02	9.13E+02
BARIUM	1.16E+02	1.09E+02	7.90E+00
CADMIUM	1.93E+02	9.54E+01	3.06E+03
CALCIUM	3.22E+04	3.57E+04	5.24E+04
CHROMIUM	4.11E+02	4.62E+02	4.62E+02
COBALT	3.66E+01	4.31E+01	3.63E+01
COPPER	4.69E+03	5.08E+03	4.75E+03
GOLD	0.00E+00	6.87E+00	0.00E+00
IRON	5.59E+04	5.64E+04	6.36E+04
LEAD	6.96E+02	7.16E+02	8.82E+01
MAGNESIUM	1.27E+04	1.52E+04	3.43E+02
MANGANESE	3.09E+02	3.61E+02	3.06E+02
NICKEL	1.78E+02	2.19E+02	1.45E+02
PHOSPHOROUS	6.39E+04	6.15E+04	6.11E+04
SELENIUM	0.00E+00	0.00E+00	0.00E+00
SILVER	6.18E+00	1.20E+01	1.61E+00
SODIUM	4.78E+03	5.13E+03	2.67E+03
SULFUR	2.75E+04	6.05E+03	2.11E+04
TIN	2.81E+02	2.89E+02	9.10E+02
TITANIUM	7.04E+03	7.03E+03	6.51E+03
VANADIUM	4.39E+02	4.89E+02	6.73E+02
ZINC	6.25E+03	6.57E+03	6.24E+03

TABLE 2.15 (a) TRACE METALS CONTENT OF PARTICULATE MATTER BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION BASIS)
RUN: 2

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL[a]	1	2	3	4	5	TOTAL[a]
METAL	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g
ALUMINUM	6.46E+02	2.21E+03	4.92E+04	4.98E+04	0.00E+00	6.69E+03	2.85E+03	0.00E+00	0.00E+00	1.03E+05	0.00E+00	6.12E+04
ANTIMONY	2.44E+02	2.68E+02	1.66E+02	5.43E+02	0.00E+00	2.80E+02	7.71E+02	0.00E+00	0.00E+00	6.14E+02	0.00E+00	6.79E+02
ARSENIC	7.82E+02	9.11E+02	1.28E+03	4.78E+02	6.10E-01		1.17E+02	0.00E+00	0.00E+00	9.33E+02	0.00E+00	5.93E+02
BARIUM	7.09E+01	1.19E+02	1.53E+03	2.85E+03	0.00E+00	3.88E+02	2.52E+01	0.00E+00	0.00E+00	5.89E+02	0.00E+00	3.54E+02
CADMIUM	1.67E+03	4.91E+03	1.24E+04	3.93E+04	0.00E+00	6.49E+03	1.21E+04	0.00E+00	0.00E+00	2.90E+04	2.00E-02	
CALCIUM	6.45E+05	7.59E+04	7.72E+04	7.72E+04	2.10E-01		1.32E+04	0.00E+00	0.00E+00	0.00E+00	9.00E-02	
CHROMIUM	4.05E+02	4.31E+02	1.78E+03	5.59E+02	5.54E+01		2.63E+03	0.00E+00	0.00E+00	9.63E+01	4.70E-02	
COBALT	3.63E+01	4.91E+01	5.61E+01	4.46E+01	9.70E-01		0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E+00	
COPPER	4.65E+03	5.01E+03	7.61E+03	1.15E+04	7.70E-02		1.70E+02	0.00E+00	0.00E+00	1.04E+04	1.70E-02	
GOLD	2.05E+01	9.88E+00	0.00E+00	1.19E+01	0.00E+00	1.68E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	7.96E+04	6.68E+04	9.58E+04	1.23E+04	2.11E+02		1.07E+04	0.00E+00	0.00E+00	8.81E+03	4.38E-01	
LEAD	1.47E+03	3.63E+03	8.44E+03	2.81E+04	0.00E+00	4.84E+03	3.40E+02	0.00E+00	0.00E+00	1.86E+04	0.00E+00	1.10E+04
MAGNESIUM	2.63E+04	2.70E+04	2.65E+04	7.39E+03	0.00E+00	2.45E+04	1.18E+04	0.00E+00	0.00E+00	0.00E+00	6.00E-03	
MANGANESE	4.25E+02	4.78E+02	3.92E+02	1.47E+01	6.05E+00		6.24E+02	0.00E+00	0.00E+00	1.90E+01	7.00E-03	
NICKEL	2.17E+02	4.11E+02	7.33E+02	1.66E+03	2.59E+01		1.54E+03	0.00E+00	0.00E+00	8.34E+01	3.50E-02	
PHOSPHOROUS	6.47E+04	6.60E+04	7.56E+04	1.27E+04	7.22E+00		1.16E+04	0.00E+00	0.00E+00	1.32E+04	0.00E+00	1.25E+04
SELENIUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.93E+02
SILVER	1.54E+02	4.27E+02	3.67E+02	5.28E+02	0.00E+00	2.62E+02	1.55E+01	0.00E+00	0.00E+00	4.90E+02	0.00E+00	2.93E+02
SODIUM	8.10E+03	3.95E+03	1.38E+04	3.49E+04	0.00E+00	9.93E+03	1.65E+04	0.00E+00	0.00E+00	9.86E+03	2.12E-01	
SULFUR	2.37E+04	3.75E+04	6.06E+04	6.97E+04	1.31E+03		9.74E+04	0.00E+00	0.00E+00	1.09E+05	3.02E-01	
TIN	3.91E+02	7.49E+02	1.82E+03	9.80E+03	0.00E+00	1.47E+03	3.88E+01	0.00E+00	0.00E+00	6.46E+03	0.00E+00	3.79E+03
TITANIUM	7.64E+03	7.22E+03	8.75E+03	5.90E+02	0.00E+00	6.92E+03	3.98E+02	0.00E+00	0.00E+00	6.88E+02	0.00E+00	5.67E+02
VANADIUM	7.75E+02	1.48E+03	2.50E+03	7.55E+03	0.00E+00	1.67E+03	1.54E+03	0.00E+00	0.00E+00	4.85E+03	0.00E+00	3.48E+03
ZINC	6.92E+03	8.34E+03	1.11E+04	1.59E+04	9.00E-02		5.07E+04	0.00E+00	0.00E+00	1.24E+04	2.58E-01	

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

[a] See note a in Table 6.1B.

TABLE 2.2S (a) TRACE METALS AND TOTAL PARTICULATE CONCENTRATIONS IN FLUE GAS BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION)
RUN: 2

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)						GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)					
ALUMINUM	1.23E-04	1.61E-04	1.71E-04	1.54E-03	0.00E+00	2.00E-03	9.46E-06	0.00E+00	0.00E+00	4.79E-04	0.00E+00	4.88E-04
ANTIMONY	4.66E-05	1.95E-05	5.76E-07	1.68E-05	0.00E+00	8.35E-05	2.56E-06	0.00E+00	0.00E+00	2.86E-06	0.00E+00	5.42E-06
ARSENIC	1.49E-04	6.62E-05	4.44E-06	1.48E-05	5.72E-05	2.92E-04	3.87E-07	0.00E+00	0.00E+00	4.35E-06	0.00E+00	4.73E-06
BARIUM	1.35E-05	8.63E-06	5.32E-06	8.82E-05	0.00E+00	1.16E-04	8.38E-08	0.00E+00	0.00E+00	2.74E-06	0.00E+00	2.82E-06
CADMIUM	3.20E-04	3.57E-04	4.29E-05	1.22E-03	0.00E+00	1.94E-03	4.03E-05	0.00E+00	0.00E+00	1.35E-04	1.13E-06	1.77E-04
CALCIUM	1.23E-01	5.51E-03	2.68E-04	2.39E-03	1.97E-05	1.31E-01	4.37E-05	0.00E+00	0.00E+00	0.00E+00	5.09E-06	4.88E-05
CHROMIUM	7.73E-05	3.13E-05	6.19E-06	1.73E-05	5.19E-03	5.33E-03	8.88E-06	0.00E+00	0.00E+00	4.49E-07	2.66E-06	1.20E-05
COBALT	6.93E-06	3.57E-06	1.95E-07	1.38E-06	9.10E-05	1.03E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.81E-05	7.81E-05
COPPER	8.89E-04	3.64E-04	2.64E-05	3.56E-04	7.22E-06	1.64E-03	5.65E-07	0.00E+00	0.00E+00	4.83E-05	9.62E-07	4.98E-05
GOLD	3.92E-06	7.18E-07	0.00E+00	3.66E-07	0.00E+00	5.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	1.52E-02	4.86E-03	3.32E-04	3.79E-04	1.98E-02	4.05E-02	3.56E-05	0.00E+00	0.00E+00	4.11E-05	2.48E-05	1.01E-04
LEAD	2.81E-04	2.64E-04	2.93E-05	8.69E-04	0.00E+00	1.44E-03	1.13E-06	0.00E+00	0.00E+00	8.66E-05	0.00E+00	8.78E-05
MAGNESIUM	5.03E-03	1.96E-03	9.19E-05	2.28E-04	0.00E+00	7.31E-03	3.92E-05	0.00E+00	0.00E+00	0.00E+00	3.39E-07	3.96E-05
MANGANESE	8.12E-05	3.47E-05	1.36E-06	4.55E-07	5.67E-04	6.85E-04	2.07E-06	0.00E+00	0.00E+00	8.83E-08	3.96E-07	2.56E-06
NICKEL	4.14E-05	2.99E-05	2.54E-06	5.14E-05	2.42E-03	2.54E-03	5.11E-06	0.00E+00	0.00E+00	3.89E-07	1.98E-06	7.48E-06
PHOSPHOROUS	1.24E-02	4.80E-03	2.62E-04	3.93E-04	6.77E-04	1.85E-02	3.84E-05	0.00E+00	0.00E+00	6.15E-05	0.00E+00	9.99E-05
SELENIUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.12E-06
SILVER	2.94E-05	3.10E-05	1.27E-06	1.63E-05	0.00E+00	7.80E-05	5.16E-08	0.00E+00	0.00E+00	2.28E-06	0.00E+00	2.34E-06
SODIUM	1.55E-03	2.87E-04	4.80E-05	1.08E-03	0.00E+00	2.96E-03	5.48E-05	0.00E+00	0.00E+00	4.59E-05	1.20E-05	1.13E-04
SULFUR	4.52E-03	2.73E-03	2.10E-04	2.15E-03	1.23E-01	1.32E-01	3.24E-04	0.00E+00	0.00E+00	5.09E-04	1.71E-03	2.54E-03
TIN	7.46E-05	5.44E-05	6.31E-06	3.03E-04	0.00E+00	4.38E-04	1.29E-07	0.00E+00	0.00E+00	3.01E-05	0.00E+00	3.02E-05
TITANIUM	1.46E-03	5.25E-04	3.04E-05	1.82E-05	0.00E+00	2.03E-03	1.32E-06	0.00E+00	0.00E+00	3.20E-06	0.00E+00	4.53E-06
VANADIUM	1.48E-04	1.08E-04	8.69E-06	2.33E-04	0.00E+00	4.98E-04	5.13E-06	0.00E+00	0.00E+00	2.26E-05	0.00E+00	2.77E-05
ZINC	1.32E-03	6.06E-04	3.85E-05	4.93E-04	8.44E-06	2.47E-03	1.68E-04	0.00E+00	0.00E+00	5.79E-05	1.46E-05	2.41E-04
Metals[a] (gm/dscm)	1.67E-01	2.28E-02	1.59E-03	1.19E-02	1.52E-01	3.55E-01	7.88E-04	0.00E+00	0.00E+00	1.53E-03	1.85E-03	
Tot.Mass[a] (gm/dscm)	1.91E-01	7.27E-02	3.47E-03	3.09E-02	-	2.98E-01	3.32E-03	0.00E+00	0.00E+00	4.66E-03	-	7.98E-03

FLUE GAS FLOW RATE (dscmm) 7.57E+01

FLUE GAS FLOW RATE (dscmm) 2.27E+02

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[a] See notes a and b in Table 6.2B.

TABLE 2.3S (a) DISTRIBUTION OF TRACE METALS AND TOTAL PARTICULATE BY PARTICULATE SIZE FRACTION (SASS SIZE BASIS)
RUN: 2

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	FRACTION OF METAL i IN SIZE FRACTION j						FRACTION OF METAL i IN SIZE FRACTION j					
ALUMINUM	6.18E-02	8.07E-02	8.56E-02	7.72E-01	0.00E+00	1.00E+00	1.94E-02	0.00E+00	0.00E+00	9.81E-01	0.00E+00	1.00E+00
ANTIMONY	5.58E-01	2.34E-01	6.90E-03	2.01E-01	0.00E+00	1.00E+00	4.72E-01	0.00E+00	0.00E+00	5.28E-01	0.00E+00	1.00E+00
ARSENIC	5.12E-01	2.27E-01	1.52E-02	5.05E-02	1.96E-01	1.00E+00	8.17E-02	0.00E+00	0.00E+00	9.18E-01	0.00E+00	1.00E+00
BARIUM	1.17E-01	7.46E-02	4.60E-02	7.62E-01	0.00E+00	1.00E+00	2.97E-02	0.00E+00	0.00E+00	9.70E-01	0.00E+00	1.00E+00
CADMIUM	1.65E-01	1.85E-01	2.22E-02	6.28E-01	0.00E+00	1.00E+00	2.28E-01	0.00E+00	0.00E+00	7.66E-01	6.41E-03	1.00E+00
CALCIUM	9.38E-01	4.19E-02	2.04E-03	1.82E-02	1.50E-04	1.00E+00	8.96E-01	0.00E+00	0.00E+00	0.00E+00	1.04E-01	1.00E+00
CHROMIUM	1.45E-02	5.89E-03	1.16E-03	3.24E-03	9.75E-01	1.00E+00	7.41E-01	0.00E+00	0.00E+00	3.74E-02	2.22E-01	1.00E+00
COBALT	6.73E-02	3.46E-02	1.89E-03	1.34E-02	8.83E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00
COPPER	5.41E-01	2.22E-01	1.61E-02	2.17E-01	4.39E-03	1.00E+00	1.13E-02	0.00E+00	0.00E+00	9.69E-01	1.93E-02	1.00E+00
GOLD	7.83E-01	1.44E-01	0.00E+00	7.32E-02	0.00E+00	1.00E+00	ND	ND	ND	ND	ND	ND
IRON	3.75E-01	1.20E-01	8.20E-03	9.36E-03	4.88E-01	1.00E+00	3.51E-01	0.00E+00	0.00E+00	4.05E-01	2.44E-01	1.00E+00
LEAD	1.95E-01	1.83E-01	2.03E-02	6.02E-01	0.00E+00	1.00E+00	1.29E-02	0.00E+00	0.00E+00	9.87E-01	0.00E+00	1.00E+00
MAGNESIUM	6.88E-01	2.69E-01	1.26E-02	3.12E-02	0.00E+00	1.00E+00	9.91E-01	0.00E+00	0.00E+00	0.00E+00	8.58E-03	1.00E+00
MANGANESE	1.18E-01	5.07E-02	1.99E-03	6.65E-04	8.28E-01	1.00E+00	8.10E-01	0.00E+00	0.00E+00	3.46E-02	1.55E-01	1.00E+00
NICKEL	1.63E-02	1.18E-02	1.00E-03	2.02E-02	9.51E-01	1.00E+00	6.83E-01	0.00E+00	0.00E+00	5.19E-02	2.65E-01	1.00E+00
PHOSPHOROUS	6.68E-01	2.60E-01	1.42E-02	2.12E-02	3.66E-02	1.00E+00	3.84E-01	0.00E+00	0.00E+00	6.16E-01	0.00E+00	1.00E+00
SELENIUM	ND	ND	ND	ND	ND	ND	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
SILVER	3.77E-01	3.98E-01	1.63E-02	2.09E-01	0.00E+00	1.00E+00	2.21E-02	0.00E+00	0.00E+00	9.78E-01	0.00E+00	1.00E+00
SODIUM	5.22E-01	9.69E-02	1.62E-02	3.65E-01	0.00E+00	1.00E+00	4.86E-01	0.00E+00	0.00E+00	4.08E-01	1.06E-01	1.00E+00
SULFUR	3.41E-02	2.06E-02	1.59E-03	1.63E-02	9.27E-01	1.00E+00	1.27E-01	0.00E+00	0.00E+00	2.00E-01	6.72E-01	1.00E+00
TIN	1.70E-01	1.24E-01	1.44E-02	6.91E-01	0.00E+00	1.00E+00	4.26E-03	0.00E+00	0.00E+00	9.96E-01	0.00E+00	1.00E+00
TITANIUM	7.18E-01	2.58E-01	1.49E-02	8.97E-03	0.00E+00	1.00E+00	2.92E-01	0.00E+00	0.00E+00	7.08E-01	0.00E+00	1.00E+00
VANADIUM	2.97E-01	2.17E-01	1.74E-02	4.69E-01	0.00E+00	1.00E+00	1.85E-01	0.00E+00	0.00E+00	8.15E-01	0.00E+00	1.00E+00
ZINC	5.35E-01	2.46E-01	1.56E-02	2.00E-01	3.42E-03	1.00E+00	6.99E-01	0.00E+00	0.00E+00	2.40E-01	6.06E-02	1.00E+00

FRACTION OF ELEMENT i IN SIZE FRACTION j = MASS OF ELEMENT i IN SASS SIZE FRACTION j
DIVIDED BY TOTAL MASS OF ELEMENT i IN ALL SASS SIZE FRACTIONS

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

TABLE 2.5 TRACE METALS CONTENT OF SLUDGE, BOTTOM ASH AND BAGHOUSE BOTTOM DUST

RUN 2

	FEED SLUDGE	BOTTOM ASH	BAGHOUSE DUST
METAL	PPM	PPM	PPM
ALUMINUM	N/A	4.15E+03	N/A
ANTIMONY	N/A	2.48E+02	N/A
ARSENIC	N/A	7.49E+02	N/A
BARIUM	N/A	2.83E+02	N/A
CADMIUM	N/A	1.06E+02	N/A
CALCIUM	N/A	4.95E+04	N/A
CHROMIUM	N/A	5.27E+02	N/A
COBALT	N/A	5.07E+01	N/A
COPPER	N/A	4.82E+03	N/A
GOLD	N/A	1.02E+01	N/A
IRON	N/A	5.72E+04	N/A
LEAD	N/A	8.52E+02	N/A
MAGNESIUM	N/A	1.84E+04	N/A
MANGANESE	N/A	4.37E+02	N/A
NICKEL	N/A	2.92E+02	N/A
PHOSPHOROUS	N/A	7.50E+04	N/A
SELENIUM	N/A	0.00E+00	N/A
SILVER	N/A	3.68E+01	N/A
SODIUM	N/A	5.06E+03	N/A
SULFUR	N/A	4.15E+03	N/A
TIN	N/A	3.39E+02	N/A
TITANIUM	N/A	7.83E+03	N/A
VANADIUM	N/A	7.14E+02	N/A
ZINC	N/A	6.74E+03	N/A

TABLE 3.15 (a) TRACE METALS CONTENT OF PARTICULATE MATTER BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION BASIS)
RUN: 3

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL[a]	1	2	3	4	5	TOTAL[a]
METAL	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g
ALUMINUM	1.46E+03	1.32E+03	2.56E+04	8.35E+03	0.00E+00	3.14E+03	9.52E+03	0.00E+00	0.00E+00	1.79E+04	0.00E+00	1.66E+04
ANTIMONY	2.88E+02	2.62E+02	2.48E+02	3.78E+02	0.00E+00	2.89E+02	3.05E+03	0.00E+00	0.00E+00	1.91E+02	0.00E+00	6.38E+02
ARSENIC	9.55E+02	8.73E+02	8.62E+02	3.43E+02	0.00E+00	8.69E+02	0.00E+00	0.00E+00	0.00E+00	2.98E+02	0.00E+00	2.51E+02
BARIUM	7.89E+01	9.95E+01	1.40E+02	9.76E+02	0.00E+00	1.77E+02	6.32E+02	0.00E+00	0.00E+00	1.47E+03	0.00E+00	1.34E+03
CADMIUM	1.91E+03	5.27E+03	1.17E+04	2.98E+04	2.10E-02		2.03E+04	0.00E+00	0.00E+00	7.92E+03	0.00E+00	9.86E+03
CALCIUM	5.78E+04	5.83E+04	8.46E+04	0.00E+00	5.33E-01		9.93E+04	0.00E+00	0.00E+00	0.00E+00	1.05E-01	
CHROMIUM	4.73E+02	4.25E+02	6.65E+02	4.30E+02	6.33E+00		1.88E+04	0.00E+00	0.00E+00	0.00E+00	2.39E-01	
COBALT	4.48E+01	4.87E+01	5.55E+01	3.95E+01	1.55E-01		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
COPPER	4.41E+03	5.08E+03	6.02E+03	1.12E+04	3.80E-02		1.03E+03	0.00E+00	0.00E+00	3.11E+03	1.70E-01	
GOLD	9.75E+00	5.10E+00	0.00E+00	1.01E+01	0.00E+00	8.23E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	7.36E+04	7.14E+04	6.90E+04	7.22E+03	2.85E+01		6.77E+04	0.00E+00	0.00E+00	3.80E+03	8.70E-01	
LEAD	1.40E+03	3.10E+03	6.40E+03	1.93E+04	0.00E+00	3.83E+03	2.11E+03	0.00E+00	0.00E+00	4.69E+03	0.00E+00	4.28E+03
MAGNESIUM	2.47E+04	2.40E+04	3.60E+03	0.00E+00	1.59E-01		3.14E+04	0.00E+00	0.00E+00	0.00E+00	1.20E-02	
MANGANESE	4.40E+02	4.45E+02	4.49E+02	1.12E+02	6.03E-01		0.00E+00	0.00E+00	0.00E+00	9.06E+01	5.60E-02	
NICKEL	1.87E+02	4.00E+02	3.20E+02	1.03E+03	3.29E+00		0.00E+00	0.00E+00	0.00E+00	2.13E+02	6.33E-01	
PHOSPHOROUS	6.35E+04	7.31E+04	7.30E+04	1.28E+04	5.26E+00		2.00E+04	0.00E+00	0.00E+00	7.33E+03	0.00E+00	9.31E+03
SELENIUM	0.00E+00	1.56E+01	0.00E+00	4.75E+01	0.00E+00	8.60E+00	5.95E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.29E+02
SILVER	1.06E+01	1.72E+02	1.51E+02	0.00E+00	0.00E+00	5.49E+01	2.53E+02	0.00E+00	0.00E+00	1.51E+02	0.00E+00	1.67E+02
SODIUM	6.82E+03	3.96E+03	3.50E+03	5.32E+03	0.00E+00	5.83E+03	1.82E+04	0.00E+00	0.00E+00	1.27E+05	0.00E+00	1.10E+05
SULFUR	1.66E+04	3.45E+04	4.70E+04	7.50E+04	6.47E+02		1.86E+05	0.00E+00	0.00E+00	1.86E+04	1.52E+01	
TIN	3.33E+02	7.00E+02	1.48E+03	6.35E+03	0.00E+00	1.11E+03	0.00E+00	0.00E+00	0.00E+00	1.40E+03	0.00E+00	1.18E+03
TITANIUM	6.89E+03	7.46E+03	7.49E+03	1.26E+03	0.00E+00	6.49E+03	5.47E+02	0.00E+00	0.00E+00	4.92E+02	0.00E+00	5.00E+02
VANADIUM	7.29E+02	1.24E+03	1.66E+03	4.88E+03	0.00E+00	1.31E+03	3.22E+03	0.00E+00	0.00E+00	1.36E+03	0.00E+00	1.65E+03
ZINC	7.19E+03	8.58E+03	9.19E+03	1.38E+04	2.56E-01		9.13E+04	0.00E+00	0.00E+00	3.15E+03	7.80E-02	

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

[a] See note a in Table 6.1B.

TABLE 3.2S (a) TRACE METALS AND TOTAL PARTICULATE CONCENTRATIONS IN FLUE GAS BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION)
RUN: 3

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)						GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)					
ALUMINUM	3.07E-04	1.11E-04	3.73E-04	2.90E-04	0.00E+00	1.08E-03	7.91E-06	0.00E+00	0.00E+00	8.02E-05	0.00E+00	8.81E-05
ANTIMONY	6.08E-05	2.21E-05	3.63E-06	1.31E-05	0.00E+00	9.96E-05	2.54E-06	0.00E+00	0.00E+00	8.57E-07	0.00E+00	3.39E-06
ARSENIC	2.01E-04	7.35E-05	1.26E-05	1.19E-05	0.00E+00	2.99E-04	0.00E+00	0.00E+00	0.00E+00	1.34E-06	0.00E+00	1.34E-06
BARIUM	1.66E-05	8.37E-06	2.04E-06	3.39E-05	0.00E+00	6.09E-05	5.25E-07	0.00E+00	0.00E+00	6.58E-06	0.00E+00	7.11E-06
CADMIUM	4.03E-04	4.44E-04	1.71E-04	1.04E-03	2.00E-06	2.06E-03	1.69E-05	0.00E+00	0.00E+00	3.56E-05	0.00E+00	5.24E-05
CALCIUM	1.22E-02	4.91E-03	1.24E-03	0.00E+00	5.07E-05	1.84E-02	8.25E-05	0.00E+00	0.00E+00	0.00E+00	6.24E-06	8.88E-05
CHROMIUM	9.98E-05	3.58E-05	9.71E-06	1.49E-05	6.02E-04	7.62E-04	1.56E-05	0.00E+00	0.00E+00	0.00E+00	1.42E-05	2.98E-05
COBALT	9.44E-06	4.10E-06	8.10E-07	1.37E-06	1.47E-05	3.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
COPPER	9.31E-04	4.28E-04	8.79E-05	3.88E-04	3.62E-06	1.84E-03	8.57E-07	0.00E+00	0.00E+00	1.40E-05	1.01E-05	2.49E-05
GOLD	2.06E-06	4.29E-07	0.00E+00	3.49E-07	0.00E+00	2.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	1.55E-02	6.02E-03	1.01E-03	2.51E-04	2.71E-03	2.55E-02	5.63E-05	0.00E+00	0.00E+00	1.70E-05	5.17E-05	1.25E-04
LEAD	2.96E-04	2.61E-04	9.35E-05	6.69E-04	0.00E+00	1.32E-03	1.75E-06	0.00E+00	0.00E+00	2.10E-05	0.00E+00	2.29E-05
MAGNESIUM	5.22E-03	2.02E-03	1.25E-04	0.00E+00	1.51E-05	7.38E-03	2.61E-05	0.00E+00	0.00E+00	0.00E+00	7.13E-07	2.68E-05
MANGANESE	9.28E-05	3.75E-05	6.55E-06	3.98E-06	5.74E-05	1.98E-04	0.00E+00	0.00E+00	0.00E+00	4.07E-07	3.33E-06	3.73E-06
NICKEL	3.95E-05	3.37E-05	1.20E-05	3.58E-05	3.13E-04	4.34E-04	0.00E+00	0.00E+00	0.00E+00	9.58E-07	3.76E-05	3.86E-05
PHOSPHOROUS	1.34E-02	6.16E-03	1.07E-03	4.44E-04	5.00E-04	2.16E-02	1.66E-05	0.00E+00	0.00E+00	3.29E-05	0.00E+00	4.96E-05
SELENIUM	0.00E+00	1.31E-06	0.00E+00	1.65E-06	0.00E+00	2.96E-06	4.94E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.94E-06
SILVER	2.24E-06	1.45E-05	2.20E-06	0.00E+00	0.00E+00	1.89E-05	2.10E-07	0.00E+00	0.00E+00	6.80E-07	0.00E+00	8.90E-07
SODIUM	1.44E-03	3.34E-04	5.11E-05	1.85E-04	0.00E+00	2.01E-03	1.51E-05	0.00E+00	0.00E+00	5.69E-04	0.00E+00	5.84E-04
SULFUR	3.50E-03	2.91E-03	6.86E-04	2.60E-03	6.15E-02	7.12E-02	1.55E-04	0.00E+00	0.00E+00	8.35E-05	9.05E-04	1.14E-03
TIN	8.19E-05	5.89E-05	2.16E-05	2.20E-04	0.00E+00	3.83E-04	0.00E+00	0.00E+00	0.00E+00	6.27E-06	0.00E+00	6.27E-06
TITANIUM	1.45E-03	6.28E-04	1.09E-04	4.38E-05	0.00E+00	2.24E-03	4.55E-07	0.00E+00	0.00E+00	2.21E-06	0.00E+00	2.66E-06
VANADIUM	1.54E-04	1.04E-04	2.42E-05	1.69E-04	0.00E+00	4.52E-04	2.68E-06	0.00E+00	0.00E+00	6.09E-06	0.00E+00	8.77E-06
ZINC	1.52E-03	7.23E-04	1.34E-04	4.79E-04	2.44E-05	2.88E-03	7.58E-05	0.00E+00	0.00E+00	1.41E-05	4.63E-06	9.46E-05
Metals[a] (gm/dscm)	5.70E-02	2.53E-02	5.23E-03	6.89E-03	6.58E-02	1.60E-01	4.81E-04	0.00E+00	0.00E+00	8.92E-04	1.03E-03	
Tot.Mass[b] (gm/dscm)	2.11E-01	8.42E-02	1.46E-02	3.47E-02	-	3.45E-01	8.31E-04	0.00E+00	0.00E+00	4.49E-03	-	5.32E-03

FLUE GAS FLOW RATE 8.48E+01
(dscmm)

FLUE GAS FLOW RATE 2.34E+02
(dscmm)

[a] See notes a and b in Table 6.2B.

TABLE 3.3S (a) DISTRIBUTION OF TRACE METALS AND TOTAL PARTICULATE BY PARTICULATE SIZE FRACTION (SASS SIZE BASIS)
RUN: 3

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	FRACTION OF METAL i IN SIZE FRACTION j						FRACTION OF METAL i IN SIZE FRACTION j					
ALUMINUM	2.84E-01	1.03E-01	3.45E-01	2.68E-01	0.00E+00	1.00E+00	8.98E-02	0.00E+00	0.00E+00	9.10E-01	0.00E+00	1.00E+00
ANTIMONY	6.10E-01	2.22E-01	3.64E-02	1.32E-01	0.00E+00	1.00E+00	7.48E-01	0.00E+00	0.00E+00	2.52E-01	0.00E+00	1.00E+00
ARSENIC	6.73E-01	2.46E-01	4.20E-02	3.97E-02	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
BARIUM	2.73E-01	1.38E-01	3.35E-02	5.56E-01	0.00E+00	1.00E+00	7.39E-02	0.00E+00	0.00E+00	9.26E-01	0.00E+00	1.00E+00
CADMIUM	1.96E-01	2.16E-01	8.33E-02	5.04E-01	9.71E-04	1.00E+00	3.22E-01	0.00E+00	0.00E+00	6.78E-01	0.00E+00	1.00E+00
CALCIUM	6.63E-01	2.67E-01	6.72E-02	0.00E+00	2.76E-03	1.00E+00	9.30E-01	0.00E+00	0.00E+00	0.00E+00	7.03E-02	1.00E+00
CHROMIUM	1.31E-01	4.69E-02	1.27E-02	1.96E-02	7.90E-01	1.00E+00	5.24E-01	0.00E+00	0.00E+00	0.00E+00	4.76E-01	1.00E+00
COBALT	3.10E-01	1.35E-01	2.66E-02	4.50E-02	4.84E-01	1.00E+00	ND	ND	ND	ND	ND	ND
COPPER	5.06E-01	2.33E-01	4.78E-02	2.11E-01	1.97E-03	1.00E+00	3.44E-02	0.00E+00	0.00E+00	5.61E-01	4.05E-01	1.00E+00
GOLD	7.25E-01	1.51E-01	0.00E+00	1.23E-01	0.00E+00	1.00E+00	ND	ND	ND	ND	ND	ND
IRON	6.09E-01	2.36E-01	3.94E-02	9.82E-03	1.06E-01	1.00E+00	4.50E-01	0.00E+00	0.00E+00	1.36E-01	4.13E-01	1.00E+00
LEAD	2.24E-01	1.98E-01	7.09E-02	5.07E-01	0.00E+00	1.00E+00	7.67E-02	0.00E+00	0.00E+00	9.23E-01	0.00E+00	1.00E+00
MAGNESIUM	7.07E-01	2.74E-01	1.70E-02	0.00E+00	2.05E-03	1.00E+00	9.73E-01	0.00E+00	0.00E+00	0.00E+00	2.66E-02	1.00E+00
MANGANESE	4.69E-01	1.89E-01	3.31E-02	1.96E-02	2.90E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-01	8.91E-01	1.00E+00
NICKEL	9.10E-02	7.76E-02	2.76E-02	8.24E-02	7.21E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	2.48E-02	9.75E-01	1.00E+00
PHOSPHOROUS	6.21E-01	2.86E-01	4.94E-02	2.06E-02	2.32E-02	1.00E+00	3.35E-01	0.00E+00	0.00E+00	6.65E-01	0.00E+00	1.00E+00
SELENIUM	ND	ND	ND	ND	ND	ND	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
SILVER	1.18E-01	7.65E-01	1.16E-01	0.00E+00	0.00E+00	1.00E+00	2.36E-01	0.00E+00	0.00E+00	7.64E-01	0.00E+00	1.00E+00
SODIUM	7.17E-01	1.66E-01	2.54E-02	9.19E-02	0.00E+00	1.00E+00	2.59E-02	0.00E+00	0.00E+00	9.74E-01	0.00E+00	1.00E+00
SULFUR	4.91E-02	4.08E-02	9.62E-03	3.65E-02	8.64E-01	1.00E+00	1.35E-01	0.00E+00	0.00E+00	7.31E-02	7.92E-01	1.00E+00
TIN	2.14E-01	1.54E-01	5.65E-02	5.76E-01	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
TITANIUM	6.51E-01	2.81E-01	4.89E-02	1.96E-02	0.00E+00	1.00E+00	1.71E-01	0.00E+00	0.00E+00	8.29E-01	0.00E+00	1.00E+00
VANADIUM	3.40E-01	2.31E-01	5.35E-02	3.75E-01	0.00E+00	1.00E+00	3.05E-01	0.00E+00	0.00E+00	6.95E-01	0.00E+00	1.00E+00
ZINC	5.27E-01	2.51E-01	4.66E-02	1.66E-01	8.46E-03	1.00E+00	8.02E-01	0.00E+00	0.00E+00	1.49E-01	4.90E-02	1.00E+00

FRACTION OF ELEMENT i IN SIZE FRACTION j = MASS OF ELEMENT i IN SASS SIZE FRACTION j
DIVIDED BY TOTAL MASS OF ELEMENT i IN ALL SASS SIZE FRACTIONS

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

TABLE 3.5 TRACE METALS CONTENT OF SLUDGE, BOTTOM ASH AND BAGHOUSE BOTTOM DUST

RUN 3

METAL	FEED SLUDGE PPM	BOTTOM ASH PPM	BAGHOUSE DUST PPM
ALUMINUM	5.92E+02	2.23E+03	N/A
ANTIMONY	1.93E+02	2.28E+02	N/A
ARSENIC	6.04E+02	7.49E+02	N/A
BARIUM	5.86E+01	8.90E+01	N/A
CADMIUM	2.18E+02	4.14E+01	N/A
CALCIUM	5.48E+04	9.84E+03	N/A
CHROMIUM	3.46E+02	4.44E+02	N/A
COBALT	3.57E+01	4.14E+01	N/A
COPPER	4.73E+03	4.99E+03	N/A
GOLD	5.34E+00	1.07E+01	N/A
IRON	6.48E+04	4.99E+04	N/A
LEAD	6.25E+02	6.22E+02	N/A
MAGNESIUM	1.90E+04	7.65E+03	N/A
MANGANESE	3.18E+02	3.48E+02	N/A
NICKEL	1.43E+02	1.29E+02	N/A
PHOSPHOROUS	6.54E+04	7.99E+04	N/A
SELENIUM	7.61E+02	0.00E+00	N/A
SILVER	0.00E+00	6.46E+01	N/A
SODIUM	6.73E+03	3.42E+03	N/A
SULFUR	2.20E+04	2.89E+03	N/A
TIN	2.45E+02	2.89E+02	N/A
TITANIUM	7.37E+03	7.81E+03	N/A
VANADIUM	4.62E+02	5.45E+02	N/A
ZINC	6.08E+03	6.25E+03	N/A

TABLE 4.1S (a) TRACE METALS CONTENT OF PARTICULATE MATTER BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION BASIS)
RUN: 4

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL[a]	1	2	3	4	5	TOTAL[a]
METAL	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g	ug/g	ug/g	ug/g	ug/g	ug/ml	ug/g
ALUMINUM	1.25E+03	1.26E+03	1.44E+04	6.78E+04	0.00E+00	8.53E+03	1.06E+03	0.00E+00	0.00E+00	1.68E+05	0.00E+00	1.53E+05
ANTIMONY	2.38E+02	2.38E+02	1.07E+02	4.76E+02	0.00E+00	2.61E+02	1.27E+03	0.00E+00	0.00E+00	5.39E+02	0.00E+00	6.04E+02
ARSENIC	8.56E+02	8.32E+02	1.17E+03	5.36E+02	0.00E+00	8.21E+02	0.00E+00	0.00E+00	0.00E+00	8.86E+02	0.00E+00	8.07E+02
BARIUM	9.37E+01	7.16E+01	5.94E+02	1.37E+03	0.00E+00	2.32E+02	1.38E+02	0.00E+00	0.00E+00	3.73E+02	0.00E+00	3.52E+02
CADMIUM	1.37E+03	4.32E+03	9.42E+03	3.35E+04	5.30E-02		6.64E+03	0.00E+00	0.00E+00	2.68E+04	0.00E+00	2.50E+04
CALCIUM	3.87E+04	6.73E+04	6.37E+04	0.00E+00	3.27E-01		3.68E+04	0.00E+00	0.00E+00	2.72E+04	9.50E-02	
CHROMIUM	6.38E+02	4.18E+02	1.33E+03	6.84E+02	2.16E+01		0.00E+00	0.00E+00	0.00E+00	7.18E+01	2.57E-01	
COBALT	4.50E+01	4.27E+01	0.00E+00	6.08E+01	4.95E-01		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
COPPER	4.22E+03	5.12E+03	7.36E+03	1.08E+04	6.10E-02		1.11E+02	0.00E+00	0.00E+00	8.46E+03	6.90E-02	
GOLD	1.43E+01	3.82E+00	0.00E+00	2.05E+01	0.00E+00	1.21E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	6.26E+04	6.20E+04	8.28E+04	1.50E+04	8.54E+01		0.00E+00	0.00E+00	0.00E+00	5.56E+03	1.32E+00	1.72E+04
LEAD	1.20E+03	2.68E+03	6.56E+03	2.17E+04	0.00E+00	3.83E+03	9.21E+02	0.00E+00	0.00E+00	1.64E+04	0.00E+00	1.50E+04
MAGNESIUM	1.66E+04	2.72E+04	2.47E+04	3.78E+03	3.90E-02		1.04E+04	0.00E+00	0.00E+00	0.00E+00	1.20E-02	
MANGANESE	4.31E+02	4.00E+02	3.94E+02	1.89E+02	1.92E+00		0.00E+00	0.00E+00	0.00E+00	7.72E+01	7.20E-02	
NICKEL	4.19E+02	3.61E+02	7.14E+02	1.36E+03	1.18E+01		0.00E+00	0.00E+00	0.00E+00	3.12E+02	5.28E-01	
PHOSPHOROUS	6.72E+04	6.94E+04	6.20E+04	1.07E+04	6.38E+00		4.60E+03	0.00E+00	0.00E+00	7.35E+03	0.00E+00	7.11E+03
SELENIUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.42E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.05E+02
SILVER	9.59E+00	2.92E+01	2.36E+02	2.39E+02	0.00E+00	4.21E+01	1.66E+02	0.00E+00	0.00E+00	3.25E+02	0.00E+00	3.11E+02
SODIUM	4.97E+03	4.55E+03	5.92E+03	4.23E+03	0.00E+00	4.80E+03	4.80E+03	0.00E+00	0.00E+00	2.57E+04	0.00E+00	2.38E+04
SULFUR	2.20E+04	3.72E+04	4.89E+04	4.80E+04	1.08E+03		5.30E+04	0.00E+00	0.00E+00	1.14E+05	2.69E+01	
TIN	3.22E+02	6.45E+02	1.50E+03	9.42E+03	0.00E+00	1.39E+03	0.00E+00	0.00E+00	0.00E+00	5.11E+03	0.00E+00	4.65E+03
TITANIUM	7.03E+03	7.48E+03	7.94E+03	1.62E+03	0.00E+00	6.58E+03	0.00E+00	0.00E+00	0.00E+00	5.99E+02	0.00E+00	5.45E+02
VANADIUM	6.58E+02	1.13E+03	2.06E+03	6.24E+03	0.00E+00	1.39E+03	9.76E+02	0.00E+00	0.00E+00	4.61E+03	1.00E-02	
ZINC	5.93E+03	7.22E+03	9.99E+03	1.38E+04	1.06E-01		2.53E+04	0.00E+00	0.00E+00	1.00E+04	5.20E-02	

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

[a] See note a in Table 6.1B.

TABLE 4.2S (a) TRACE METALS AND TOTAL PARTICULATE CONCENTRATIONS IN FLUE GAS BY PARTICULATE SIZE FRACTION (SASS SIZE FRACTION)
RUN: 4

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)						GAS CONC. OF METAL i IN SIZE FRACTION j (gm/dscm)					
ALUMINUM	2.26E-04	8.93E-05	5.95E-05	2.07E-03	0.00E+00	2.44E-03	5.72E-07	0.00E+00	0.00E+00	9.25E-04	0.00E+00	9.25E-04
ANTIMONY	4.31E-05	1.68E-05	4.42E-07	1.45E-05	0.00E+00	7.48E-05	6.86E-07	0.00E+00	0.00E+00	2.96E-06	0.00E+00	3.65E-06
ARSENIC	1.55E-04	5.88E-05	4.84E-06	1.64E-05	0.00E+00	2.35E-04	0.00E+00	0.00E+00	0.00E+00	4.87E-06	0.00E+00	4.87E-06
BARIUM	1.70E-05	5.06E-06	2.46E-06	4.19E-05	0.00E+00	6.64E-05	7.46E-08	0.00E+00	0.00E+00	2.05E-06	0.00E+00	2.13E-06
CADMIUM	2.48E-04	3.05E-04	3.90E-05	1.02E-03	4.94E-06	1.62E-03	3.59E-06	0.00E+00	0.00E+00	1.47E-04	0.00E+00	1.51E-04
CALCIUM	7.01E-03	4.76E-03	2.64E-04	0.00E+00	3.05E-05	1.21E-02	1.99E-05	0.00E+00	0.00E+00	1.49E-04	5.29E-06	1.75E-04
CHROMIUM	1.15E-04	2.96E-05	5.52E-06	2.09E-05	2.01E-03	2.19E-03	0.00E+00	0.00E+00	0.00E+00	3.95E-07	1.43E-05	1.47E-05
COBALT	8.15E-06	3.02E-06	0.00E+00	1.86E-06	4.62E-05	5.92E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
COPPER	7.64E-04	3.62E-04	3.05E-05	3.30E-04	5.69E-06	1.49E-03	5.97E-08	0.00E+00	0.00E+00	4.65E-05	3.84E-06	5.04E-05
GOLD	2.58E-06	2.70E-07	0.00E+00	6.24E-07	0.00E+00	3.48E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IRON	1.13E-02	4.38E-03	3.43E-04	4.59E-04	7.96E-03	2.45E-02	0.00E+00	0.00E+00	0.00E+00	3.06E-05	7.33E-05	1.04E-04
LEAD	2.17E-04	1.90E-04	2.72E-05	6.63E-04	0.00E+00	1.10E-03	4.97E-07	0.00E+00	0.00E+00	9.03E-05	0.00E+00	9.08E-05
MAGNESIUM	3.00E-03	1.92E-03	1.02E-04	1.15E-04	3.64E-06	5.14E-03	5.63E-06	0.00E+00	0.00E+00	0.00E+00	6.68E-07	6.30E-06
MANGANESE	7.80E-05	2.83E-05	1.63E-06	5.77E-06	1.79E-04	2.93E-04	0.00E+00	0.00E+00	0.00E+00	4.24E-07	4.01E-06	4.43E-06
NICKEL	7.58E-05	2.55E-05	2.95E-06	4.14E-05	1.10E-03	1.25E-03	0.00E+00	0.00E+00	0.00E+00	1.72E-06	2.94E-05	3.11E-05
PHOSPHOROUS	1.22E-02	4.91E-03	2.57E-04	3.26E-04	5.95E-04	1.82E-02	2.49E-06	0.00E+00	0.00E+00	4.04E-05	0.00E+00	4.29E-05
SELENIUM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.84E-06
SILVER	1.74E-06	2.07E-06	9.77E-07	7.29E-06	0.00E+00	1.21E-05	8.95E-08	0.00E+00	0.00E+00	1.79E-06	0.00E+00	1.88E-06
SODIUM	8.99E-04	3.22E-04	2.45E-05	1.29E-04	0.00E+00	1.37E-03	2.59E-06	0.00E+00	0.00E+00	1.41E-04	0.00E+00	1.44E-04
SULFUR	3.99E-03	2.63E-03	2.02E-04	1.47E-03	1.01E-01	1.09E-01	2.56E-05	0.00E+00	0.00E+00	6.25E-04	1.50E-03	2.15E-03
TIN	5.83E-05	4.56E-05	6.20E-06	2.87E-04	0.00E+00	3.97E-04	0.00E+00	0.00E+00	0.00E+00	2.81E-05	0.00E+00	2.81E-05
TITANIUM	1.27E-03	5.29E-04	3.29E-05	4.94E-05	0.00E+00	1.88E-03	0.00E+00	0.00E+00	0.00E+00	3.29E-06	0.00E+00	3.29E-06
VANADIUM	1.19E-04	7.96E-05	8.53E-06	1.90E-04	0.00E+00	3.98E-04	5.27E-07	0.00E+00	0.00E+00	2.53E-05	5.56E-07	2.64E-05
ZINC	1.07E-03	5.11E-04	4.14E-05	4.22E-04	9.88E-06	2.06E-03	1.37E-05	0.00E+00	0.00E+00	5.51E-05	2.89E-06	7.16E-05
Metals[a] (gm/dscm)	4.29E-02	2.12E-02	1.46E-03	7.68E-03	1.13E-01	1.86E-01	8.08E-05	0.00E+00	0.00E+00	2.32E-03	1.63E-03	
Tot.Mass[b] (gm/dscm)	1.81E-01	7.07E-02	4.14E-03	3.05E-02	-	2.86E-01	5.40E-04	0.00E+00	0.00E+00	5.50E-03	-	6.04E-03

FLUE GAS FLOW RATE (dscmm) 1.10E+02

FLUE GAS FLOW RATE (dscmm) 2.32E+02

[a] See notes a and b in Table 6.2B.

TABLE 4.3S (a) DISTRIBUTION OF TRACE METALS AND TOTAL PARTICULATE BY PARTICULATE SIZE FRACTION (SASS SIZE BASIS)
RUN: 4

	SCRUBBER INLET SASS SIZE FRACTIONS						SCRUBBER OUTLET SASS SIZE FRACTIONS					
	1	2	3	4	5	TOTAL	1	2	3	4	5	TOTAL
METAL	FRACTION OF METAL i IN SIZE FRACTION j						FRACTION OF METAL i IN SIZE FRACTION j					
ALUMINUM	9.24E-02	3.66E-02	2.44E-02	8.47E-01	0.00E+00	1.00E+00	6.18E-04	0.00E+00	0.00E+00	9.99E-01	0.00E+00	1.00E+00
ANTIMONY	5.75E-01	2.25E-01	5.90E-03	1.94E-01	0.00E+00	1.00E+00	1.88E-01	0.00E+00	0.00E+00	8.12E-01	0.00E+00	1.00E+00
ARSENIC	6.59E-01	2.50E-01	2.06E-02	6.96E-02	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
BARIUM	2.56E-01	7.63E-02	3.71E-02	6.31E-01	0.00E+00	1.00E+00	3.51E-02	0.00E+00	0.00E+00	9.65E-01	0.00E+00	1.00E+00
CADMIUM	1.53E-01	1.89E-01	2.41E-02	6.31E-01	3.05E-03	1.00E+00	2.38E-02	0.00E+00	0.00E+00	9.76E-01	0.00E+00	1.00E+00
CALCIUM	5.81E-01	3.94E-01	2.19E-02	0.00E+00	2.53E-03	1.00E+00	1.14E-01	0.00E+00	0.00E+00	8.56E-01	3.03E-02	1.00E+00
CHROMIUM	5.28E-02	1.35E-02	2.52E-03	9.55E-03	9.22E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	2.69E-02	9.73E-01	1.00E+00
COBALT	1.38E-01	5.11E-02	0.00E+00	3.14E-02	7.80E-01	1.00E+00	ND	ND	ND	ND	ND	ND
COPPER	5.12E-01	2.43E-01	2.04E-02	2.21E-01	3.81E-03	1.00E+00	1.18E-03	0.00E+00	0.00E+00	9.23E-01	7.61E-02	1.00E+00
GOLD	7.43E-01	7.77E-02	0.00E+00	1.80E-01	0.00E+00	1.00E+00	ND	ND	ND	ND	ND	ND
IRON	4.63E-01	1.79E-01	1.40E-02	1.87E-02	3.25E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E-01	7.06E-01	1.00E+00
LEAD	1.98E-01	1.73E-01	2.48E-02	6.04E-01	0.00E+00	1.00E+00	5.48E-03	0.00E+00	0.00E+00	9.95E-01	0.00E+00	1.00E+00
MAGNESIUM	5.83E-01	3.74E-01	1.99E-02	2.24E-02	7.08E-04	1.00E+00	8.94E-01	0.00E+00	0.00E+00	0.00E+00	1.06E-01	1.00E+00
MANGANESE	2.67E-01	9.67E-02	5.57E-03	1.97E-02	6.11E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	9.58E-02	9.04E-01	1.00E+00
NICKEL	6.08E-02	2.05E-02	2.37E-03	3.32E-02	8.83E-01	1.00E+00	0.00E+00	0.00E+00	0.00E+00	5.52E-02	9.45E-01	1.00E+00
PHOSPHOROUS	6.66E-01	2.69E-01	1.41E-02	1.79E-02	3.26E-02	1.00E+00	5.79E-02	0.00E+00	0.00E+00	9.42E-01	0.00E+00	1.00E+00
SELENIUM	ND	ND	ND	ND	ND	ND	1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00
SILVER	1.44E-01	1.71E-01	8.10E-02	6.04E-01	0.00E+00	1.00E+00	4.77E-02	0.00E+00	0.00E+00	9.52E-01	0.00E+00	1.00E+00
SODIUM	6.54E-01	2.34E-01	1.78E-02	9.39E-02	0.00E+00	1.00E+00	1.80E-02	0.00E+00	0.00E+00	9.82E-01	0.00E+00	1.00E+00
SULFUR	3.65E-02	2.41E-02	1.85E-03	1.34E-02	9.24E-01	1.00E+00	1.33E-02	0.00E+00	0.00E+00	2.90E-01	6.96E-01	1.00E+00
TIN	1.47E-01	1.15E-01	1.56E-02	7.23E-01	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
TITANIUM	6.76E-01	2.81E-01	1.75E-02	2.62E-02	0.00E+00	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	1.00E+00
VANADIUM	3.00E-01	2.00E-01	2.15E-02	4.79E-01	0.00E+00	1.00E+00	1.99E-02	0.00E+00	0.00E+00	9.59E-01	2.11E-02	1.00E+00
ZINC	5.22E-01	2.48E-01	2.01E-02	2.05E-01	4.81E-03	1.00E+00	1.91E-01	0.00E+00	0.00E+00	7.69E-01	4.04E-02	1.00E+00

FRACTION OF ELEMENT i IN SIZE FRACTION j = MASS OF ELEMENT i IN SASS SIZE FRACTION j
DIVIDED BY TOTAL MASS OF ELEMENT i IN ALL SASS SIZE FRACTIONS

SASS SIZE FRACTIONS

FRACTION 1 = PROBE RINSE + 10 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 2 = 3 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 3 = 1 MICRON CYCLONE CATCH (SOLID SAMPLE)
FRACTION 4 = FILTER CATCH (SOLID SAMPLE)
FRACTION 5 = IMPINGER CATCH + NITRIC IMPINGER RINSE (LIQUID SAMPLE)
TOTAL = SUM OF FRACTIONS 1-5

TABLE 4.5 TRACE METALS CONTENT OF SLUDGE, BOTTOM ASH AND BAGHOUSE BOTTOM DUST

RUN 4

METAL	FEED SLUDGE PPM	BOTTOM ASH PPM	BAGHOUSE DUST PPM
ALUMINUM	5.93E+02	2.06E+03	N/A
ANTIMONY	2.17E+02	2.31E+02	N/A
ARSENIC	5.54E+02	7.67E+02	N/A
BARIUM	9.04E+01	1.10E+02	N/A
CADMIUM	2.37E+02	1.07E+02	N/A
CALCIUM	5.40E+04	3.63E+04	N/A
CHROMIUM	3.87E+02	5.37E+02	N/A
COBALT	3.80E+01	4.44E+01	N/A
COPPER	4.57E+03	5.37E+03	N/A
GOLD	4.34E+00	8.31E+00	N/A
IRON	6.29E+04	5.77E+04	N/A
LEAD	7.01E+02	6.43E+02	N/A
MAGNESIUM	2.08E+04	1.23E+04	N/A
MANGANESE	3.26E+02	4.27E+02	N/A
NICKEL	1.88E+02	2.47E+02	N/A
PHOSPHOROUS	5.85E+04	8.16E+04	N/A
SELENIUM	0.00E+00	0.00E+00	N/A
SILVER	1.77E+01	5.23E+01	N/A
SODIUM	2.34E+03	5.55E+03	N/A
SULFUR	2.38E+04	4.17E+03	N/A
TIN	2.84E+02	3.14E+02	N/A
TITANIUM	6.94E+03	9.06E+03	N/A
VANADIUM	4.71E+02	5.21E+02	N/A
ZINC	6.61E+03	6.57E+03	N/A

APPENDIX B

SASS TRAIN AND PARTICULATE EMISSIONS DATA

Appendix B contains SASS train operating summary sheets for each test run (inlet and outlet location). Included in the summary sheets are particulate emission data by SASS train size fraction.

```
   RADIAN SOURCE TEST
   EPA METHOD 2-5
   (RAW DATA)
 PLANT                   :
 PLANT SITE              : NORFOLK , VA
 SAMPLING LOCATION       : BAGHOUSE INLET
 TEST #                  : HR-C-2
 DATE                    : 09/28/84
 TEST PERIOD             : 1345-1807 STOPPED 1615-1632 FOR SG CHANGE

PARAMETER                                 VALUE
---------                                 -----

Sampling time (min.)                       255
Barometric Pressure (in.Hg)                30.2
Sampling nozzle diameter (in.)             1.225
Meter Volume (cu.ft.)                      686.744
Meter Pressure (in.H2O)                    1.05
Meter Temperature (F)                      79.17647
Stack dimension (sq.in.)                   53.45629
Stack Static Pressure (in.H2O)            -6
Stack Moisture Collected (gm)              6615.9
Absolute stack pressure(in Hg)             29.75882
Average stack temperature (F)              392.647
Percent CO2                                8.37
Percent O2                                 11.3
Percent N2                                 80.33
Delps Subroutine result                    4.12952
DGM Factor                                 .991
Pitot Constant                             .84
```

```
    RADIAN SOURCE TEST
    EPA METHODS 2-5
    FINAL RESULTS
PLANT                  :
PLANT SITE             : NORFOLK , VA
SAMPLING LOCATION      : BAGHOUSE INLET
TEST #                 : HR-C-2
DATE                   : 09/28/84
TEST PERIOD            : 1345-1807 STOPPED 1615-1632 FOR SG CHANGE

    PARAMETER                  RESULT
    ---------                  ------

    Vm(dscf)                    674.4128
    Vm(dscm)                    19.09937
    Vw gas(scf)                 311.9397
    Vw gas (scm)                8.834132
    % moisture                  31.62558
    Md                          .6837442
    MWd                         29.7912
    MW                          26.06217
    Vs(fpm)                     638.8992
    Vs (mpm)                    194.7863
    Flow(acfm)                  237.1749
    Flow(acmm)                  6.716792
    Flow(dscfm)                 99.8806
    Flow(dscmm)                 2.828619
    % I                         120.1702
    % EA                        114.0594



                                          Program Revision:1/16/84
```

```
      RADIAN SOURCE TEST
      EPA METHOD 5
   PARTICULATE LOADING
     PLANT                   : HRC-2---FILTER---TOTAL
     PLANT SITE              : NORFOLK , VA
     SAMPLING LOCATION       : BAGHOUSE INLET
     TEST #                  : HR-C-2
     DATE                    : 09/28/84
     TEST PERIOD             : 1345-1807 STOPPED 1615-1632 FOR SG CHANGE

PARAMETER            Filter             Total
---------            ----------         -----

Total Grams          0.5904001          5.7194000
Grams/dscf           0.0008754          0.0084806
Grams/acf            0.0003687          0.0035714
Grains/dscf          0.0135079          0.1308551
Grains/acf           0.0056885          0.0551065
Grams/dscm           0.0309114          0.2994487
Grams/acm            0.0130176          0.1261058
Pounds/dscf          0.0000019          0.0000187
Pounds/acf           0.0000008          0.0000079
Pounds/Hr            0.0115681          0.1120639
Kilograms/Hr         0.0052473          0.0508319




                                        Program Revision:1/16/84
     RADIAN SOURCE TEST
     EPA METHOD 5
   PARTICULATE LOADING
    PLANT                   : HRC-2-  -3M-  -1M
    PLANT SITE              : NORFOLK , VA
    SAMPLING LOCATION       : BAGHOUSE INLET
    TEST #                  : HR-C-2
    DATE                    : 09/28/84
    TEST PERIOD             : 1345-1807 STOPPED 1615-1632 FOR SG CHANGE

PARAMETER            3 Micron Cyclone        1 Micron Cyclone
---------            ----------              ----

Total Grams            1.3877000               0.0662000
Grams/dscf             0.0020576               0.0000982
Grams/acf              0.0008665               0.0000413
Grains/dscf            0.0317494               0.0015146
Grains/acf             0.0133705               0.0006378
Grams/dscm             0.0726553               0.0034660
Grams/acm              0.0305971               0.0014596
Pounds/dscf            0.0000045               0.0000002
Pounds/acf             0.0000019               0.0000001
Pounds/Hr              0.0271901               0.0012971
Kilograms/Hr           0.0123333               0.0005884




                                             Program Revision:1/16/84
```

```
        RADIAN SOURCE TEST
        EPA METHOD 5
     PARTICULATE LOADING
      PLANT                      : HRC-2---->1----PROBE+10M
      PLANT SITE                 : NORFOLK , VA
      SAMPLING LOCATION          : BAGHOUSE INLET
      TEST #                     : HR-C-2
      DATE                       : 09/28/84
      TEST PERIOD                : 1345-1807 STOPPED 1615-1632 FOR SG CHANGE

  PARAMETER                                  10 Micron Cyclone
  ---------                                       -----

  Total Grams                                   3.6526000
  Grams/dscf                                    0.0054160
  Grams/acf                                     0.0022808
  Grains/dscf                                   0.0835684
  Grains/acf                                    0.0351929
  Grams/dscm                                    0.1912380
  Grams/acm                                     0.0805354
  Pounds/dscf                                   0.0000119
  Pounds/acf                                    0.0000050
  Pounds/Hr                                     0.0715678
  Kilograms/Hr                                  0.0324629




                                                    Program Revision:1/16/84
        RADIAN SOURCE TEST
        EPA METHOD 2-5
        (RAW DATA)
     PLANT                    :
     PLANT SITE               : NORFOLK , VA
     SAMPLING LOCATION        : SCURBBER OUTLET
     TEST #                   : HR-A-2
     DATE                     : 09/28/84
     TEST PERIOD              : 1345-1805

   PARAMETER
   ---------                                  VALUE
                                              -----

   Sampling time (min.)                        260
   Barometric Pressure (in.Hg)                 30.2
   Sampling nozzle diameter (in.)              .991
   Meter Volume (cu.ft.)                       1023.13
   Meter Pressure (in.H2O)                     1.95
   Meter Temperature (F)                       81.05556
   Stack dimension (sq.in.)                    1734.949
   Stack Static Pressure (in.H2O)              .03
   Stack Moisture Collected (gm)               544.5
   Absolute stack pressure(in Hg)              30.20221
   Average stack temperature (F)               168.6111
   Percent CO2                                 3
   Percent O2                                  17.77
   Percent N2                                  79.23001
   Delps Subroutine result                     5.524684
   DGM Factor                                  .988
   Pitot Constant                              .84
```

```
    RADIAN SOURCE TEST
    EPA METHODS 2-5
    FINAL RESULTS
PLANT                  :
PLANT SITE             : NORFOLK , VA
SAMPLING LOCATION      : SCURBBER OUTLET
TEST #                 : HR-A-2
DATE                   : 09/28/84
TEST PERIOD            : 1345-1805

    PARAMETER                    RESULT
    ---------                    ------

    Vm(dscf)                      1000.42
    Vm(dscm)                      28.33189
    Vw gas(scf)                   25.67318
    Vw gas (scm)                  .7270643
    % moisture                    2.502032
    Md                            .9749797
    MWd                           29.1908
    MW                            28.91081
    Vs(fpm)                       805.5711
    Vs (mpm)                      245.6009
    Flow(acfm)                    9705.727
    Flow(acmm)                    274.8662
    Flow(dscfm)                   8023.293
    Flow(dscmm)                   227.2196
    % I                           107.9347
    % EA                          564.7145
```

Program Revision: 1/16/84

```
        RADIAN SOURCE TEST
        EPA METHOD 5
     PARTICULATE LOADING
       PLANT                : HRA-2 --FILTER-----TOTAL
       PLANT SITE           : NORFOLK , VA
       SAMPLING LOCATION    : SCURBGER OUTLET
       TEST #               : HR-A-2
       DATE                 : 09/28/84
       TEST PERIOD          : 1345-1805

PARAMETER                Filter              Total
---------                ------------        -------

Total Grams              0.1319000           0.2270000
Grams/dscf               0.0001318           0.0002269
Grams/acf                0.0001090           0.0001876
Grains/dscf              0.0020344           0.0035011
Grains/acf               0.0016817           0.0028942
Grams/dscm               0.0046554           0.0080120
Grams/acm                0.0038484           0.0066232
Pounds/dscf              0.0000003           0.0000005
Pounds/acf               0.0000002           0.0000004
Pounds/Hr                0.1399507           0.2408553
Kiloqrams/Hr             0.0634812           0.1092512

                   Program Revision:  1/16/84
```

```
         RADIAN SOURCE TEST
         EPA METHOD 5
      PARTICULATE LOADING
        PLANT                  : HRA-2--PROBE RINSE ALSO>10M
        PLANT SITE             : NORFOLK , VA
        SAMPLING LOCATION      : SCURBBER OUTLET
        TEST #                 : HR-A-2
        DATE                   : 09/28/84
        TEST PERIOD            : 1345-1805

PARAMETER            10 Micron Cyclone     10 Micron Cyclone
---------            -----------------     -----

Total Grams            0.0940000            0.0940000
Grams/dscf             0.0000940            0.0000940
Grams/acf              0.0000777            0.0000777
Grains/dscf            0.0014498            0.0014498
Grains/acf             0.0011985            0.0011985
Grams/dscm             0.0033177            0.0033177
Grams/acm              0.0027426            0.0027426
Pounds/dscf            0.0000002            0.0000002
Pounds/acf             0.0000002            0.0000002
Pounds/Hr              0.0997374            0.0997374
Kilograms/Hr           0.0452406            0.0452406

     * BACK-HALF IMPINGER ANALYSIS WAS NOT REQUIRED
```

Program Revision: 1/16/84

```
           RADIAN SOURCE TEST
           EPA METHOD 2-5
            (RAW DATA)
        PLANT                  : HRC-3
        PLANT SITE             : NORFOLK , VA
        SAMPLING LOCATION      : BAGHOUSE INLET
        TEST #                 : HR-C-3
        DATE                   : 09/29/84
        TEST PERIOD            :
1300-1805 STOPPED 1420-1433 UPSET 1528-1605 FILTER CHANGE

     PARAMETER                                     VALUE
     ---------                                     -----

     Sampling time (min.)                           255
     Barometric Pressure (in.Hg)                    30.1
     Sampling nozzle diameter (in.)                 1.225
     Meter Volume (cu.Ft.)                          701.76
     Meter Pressure (in.H20)                        1.138889
     Meter Temperature (F)                          75.47222
     Stack dimension (sq.in.)                       53.45629
     Stack Static Pressure (in.H20)                -6
     Stack Moisture Collected (gm)                  6581.8
     Absolute stack pressure(in Hg)                 29.65882
     Average stack temperature (F)                  465.1111
     Percent CO2                                    7.2
     Percent O2                                     12.19
     Percent N2                                     80.61
     Delps Subroutine result                        4.355127
     DGM Factor                                     .991
     Pitot Constant                                 .84
```

```
             RADIAN SOURCE TEST
             EPA METHODS 2-5
             FINAL RESULTS
         PLANT                  : HRC-3
         PLANT SITE             : NORFOLK , VA
         SAMPLING LOCATION      : BAGHOUSE INLET
         TEST #                 : HR-C-3
         DATE                   : 09/29/84
         TEST PERIOD            :
1300-1805 STOPPED 1420-1433 UPSET 1528-1605 FILTER CHANGE

             PARAMETER                  RESULT
             ---------                  ------

             Vm(dscf)                    691.7844
             Vm(dscm)                    19.59133
             Vw gas(scf)                 310.3319
             Vw gas (scm)                8.788598
             % moisture                  30.96765
             Md                          .6903235
             MWd                         29.6396
             MW                          26.03509
             Vs(fpm)                     675.2896
             Vs (mpm)                    205.881
             Flow(acfm)                  250.6839
             Flow(acmm)                  7.099367
             Flow(dscfm)                 97.90647
             Flow(dscmm)                 2.772711
             % I                         125.751
             % EA                        134.0881
```

Program Revision: 1/16/84

```
        RADIAN SOURCE TEST
         EPA METHOD 5
     PARTICULATE LOADING
      PLANT               : HRC-3---FILTER----TOTAL
      PLANT SITE          : NORFOLK , VA
      SAMPLING LOCATION   : BAGHOUSE INLET
      TEST #              : HR-C-3
      DATE                : 09/29/84
      TEST PERIOD         :
1300-1805 STOPPED 1420-1433 UPSET 1528-1605 FILTER CHANGE

          PARAMETER            Filter            Total
          ---------          ----------          -----

          Total Grams         0.6802001         6.7756000
          Grams/dscf          0.0009833         0.0097944
          Grams/acf           0.0003840         0.0038253
          Grains/dscf         0.0151716         0.1511273
          Grains/acf          0.0059254         0.0590239
          Grams/dscm          0.0347187         0.3458396
          Grams/acm           0.0135597         0.1350703
          Pounds/dscf         0.0000022         0.0000216
          Pounds/acf          0.0000008         0.0000084
          Pounds/Hr           0.0127361         0.1268669
          Kilograms/Hr        0.0057771         0.0575464
```

Program Revision: 1/16/84

RADIAN SOURCE TEST
EPA METHOD 5
PARTICULATE LOADING

PLANT : HRC-3------3M-----1M
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : BAGHOUSE INLET
TEST # : HR-C-3
DATE : 09/29/84
TEST PERIOD :
1300-1805 STOPPED 1420-1433 UPSET 1528-1605 FILTER CHANGE

PARAMETER	**3 Micron Cyclone**	**1 Micron Cyclone**
Total Grams	1.6501000	0.2866000
Grams/dscf	0.0023853	0.0004143
Grams/acf	0.0009316	0.0001618
Grains/dscf	0.0368049	0.0063925
Grains/acf	0.0143744	0.0024966
Grams/dscm	0.0842243	0.0146286
Grams/acm	0.0328944	0.0057133
Pounds/dscf	0.0000053	0.0000009
Pounds/acf	0.0000021	0.0000004
Pounds/Hr	0.0308966	0.0053663
Kilograms/Hr	0.0140146	0.0024341

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```
                RADIAN  SOURCE  TEST
                  EPA  METHOD  5
              PARTICULATE  LOADING
                PLANT                 : HRC-3----->1---PROBE+10M
                PLANT SITE            : NORFOLK , VA
                SAMPLING LOCATION     : BAGHOUSE INLET
                TEST #                : HR-C-3
                DATE                  : 09/29/84
                TEST PERIOD           :
1300-1805 STOPPED 1420-1433 UPSET 1528-1605 FILTER CHANGE


          PARAMETER                           10 Micron Cyclone
          ---------                              ------

          Total Grams                            4.1304000
          Grams/dscf                             0.0059706
          Grams/acf                              0.0023319
          Grains/dscf                            0.0921271
          Grains/acf                             0.0359809
          Grams/dscm                             0.2108236
          Grams/acm                              0.0823387
          Pounds/dscf                            0.0000132
          Pounds/acf                             0.0000051
          Pounds/Hr                              0.0773380
          Kilograms/Hr                           0.0350803



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```

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : HRA-3
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : SCURBBER OUTLET
TEST # : HR-A-3
DATE : 09/29/84
TEST PERIOD : 1300-1735 STOPPED 1415-1430 DUE TO UPSET

PARAMETER	VALUE
Sampling time (min.)	260
Barometric Pressure (in.Hg)	30.1
Sampling nozzle diameter (in.)	.991
Meter Volume (cu.ft.)	989.1851
Meter Pressure (in.H2O)	1.9
Meter Temperature (F)	73.5
Stack dimension (sq.in.)	1734.949
Stack Static Pressure (in.H2O)	.03
Stack Moisture Collected (gm)	494.8
Absolute stack pressure(in Hg)	30.10221
Average stack temperature (F)	165.3889
Percent CO2	3
Percent O2	17.8
Percent N2	79.2
Delps Subroutine result	5.651108
DGM Factor	.988
Pitot Constant	.84

```
   RADIAN  SOURCE  TEST
   EPA  METHODS  2-5
   FINAL  RESULTS
PLANT                : HRA-3
PLANT SITE           : NORFOLK , VA
SAMPLING LOCATION    : SCURBBER OUTLET
TEST #               : HR-A-3
DATE                 : 09/29/84
TEST PERIOD          : 1300-1735 STOPPED 1415-1430 DUE TO UPSET

   PARAMETER                   RESULT
   ---------                   ------

   Vm(dscf)                     977.5748
   Vm(dscm)                     27.68492
   Vw gas(scf)                  23.32982
   Vw gas (scm)                 .6607005
   % moisture                   2.330874
   Md                           .9766913
   MWd                          29.192
   MW                           28.93113
   Vs(fpm)                      825.0829
   Vs (mpm)                     251.5497
   Flow(acfm)                   9940.311
   Flow(acmm)                   281.5238
   Flow(dscfm)                  8247.068
   Flow(dscmm)                  233.557
   % I                          102.6082
   % EA                         572.5684




                                           Program Revision:1/16/84
```

```
      RADIAN SOURCE TEST
       EPA METHOD 5
   PARTICULATE LOADING
     PLANT                  : HRA-3----FILTER----TOTAL
     PLANT SITE             : NORFOLK , VA
     SAMPLING LOCATION      : SCURBBER OUTLET
     TEST #                 : HR-A-3
     DATE                   : 09/29/84
     TEST PERIOD            : 1300-1735 STOPPED 1415-1430 DUE TO UPSET

PARAMETER                Filter               Total
---------             ------------           ------

Total Grams             0.1242000            0.1487000
Grams/dscf              0.0001270            0.0001521
Grams/acf               0.0001054            0.0001262
Grains/dscf             0.0019604            0.0023471
Grains/acf              0.0016264            0.0019472
Grams/dscm              0.0044861            0.0053710
Grams/acm               0.0037217            0.0044559
Pounds/dscf             0.0000003            0.0000003
Pounds/acf              0.0000002            0.0000003
Pounds/Hr               0.1386216            0.1659665
Kilograms/Hr            0.0628784            0.0752819



                                                 Program Revision:1/16/84
```

```
        RADIAN  SOURCE  TEST
        EPA  METHOD  5
     PARTICULATE  LOADING
      PLANT                  : HRA-3-PROBE RINSE ALSO>10M
      PLANT SITE             : NORFOLK , VA
      SAMPLING LOCATION      : SCURBBER OUTLET
      TEST #                 : HR-A-3
      DATE                   : 09/29/84
      TEST PERIOD            : 1300-1735 STOPPED 1415-1430 DUE TO UPSET

PARAMETER          10 Micron Cyclone       10 Micron Cyclone
---------          -----------------       -----

Total Grams            0.0230000               0.0230000
Grams/dscf             0.0000235               0.0000235
Grams/acf              0.0000195               0.0000195
Grains/dscf            0.0003630               0.0003630
Grains/acf             0.0003012               0.0003012
Grams/dscm             0.0008308               0.0008308
Grams/acm              0.0006892               0.0006892
Pounds/dscf            0.0000001               0.0000001
Pounds/acf             0.0000000               0.0000000
Pounds/Hr              0.0256707               0.0256707
Kilograms/Hr           0.0116441               0.0116441

     # BACK-HALF IMPINGER ANALYSIS WAS NOT REQUIRED




                                              Program Revision:1/16/84
```

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT :
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : BAGHOUSE INLET
TEST # : HR-C-4
DATE : 10/1/84
TEST PERIOD :
1300-1754 STOPPED 1536-1609 FOR FILTER AND SG CHANGE

PARAMETER	VALUE
Sampling time (min.)	255
Barometric Pressure (in.Hg)	29.95
Sampling nozzle diameter (in.)	1.225
Meter Volume (cu.ft.)	712.081
Meter Pressure (in.H2O)	1.170588
Meter Temperature (F)	81.77778
Stack dimension (sq.in.)	53.45629
Stack Static Pressure (in.H2O)	-6
Stack Moisture Collected (gm)	6600.2
Absolute stack pressure(in Hg)	29.50882
Average stack temperature (F)	473.3333
Percent CO2	6.27
Percent O2	12.97
Percent N2	80.76
Delps Subroutine result	4.320493
DGM Factor	.991
Pitot Constant	.84

```
        RADIAN SOURCE TEST
        EPA METHODS 2-5
        FINAL RESULTS
      PLANT                  :
      PLANT SITE             : NORFOLK , VA
      SAMPLING LOCATION      : BAGHOUSE INLET
      TEST #                 : HR-C-4
      DATE                   : 10/1/84
      TEST PERIOD            :
1300-1754 STOPPED 1536-1609 FOR FILTER AND SG CHANGE

          PARAMETER                  RESULT
          ---------                  ------

          Vm(dscf)                    690.3946
          Vm(dscm)                    19.55198
          Vw gas(scf)                 311.1994
          Vw gas (scm)                8.813168
          % moisture                  31.07042
          Md                          .6892958
          MWd                         29.522
          MW                          25.94207
          Vs(fpm)                     672.8233
          Vs (mpm)                    205.1291
          Flow(acfm)                  249.7683
          Flow(acmm)                  7.073439
          Flow(dscfm)                 96.05732
          Flow(dscmm)                 2.720343
          % I                         127.9142
          % EA                        155.3174
```

Program Revision: 1/16/84

```
          RADIAN SOURCE TEST
          EPA METHOD 5
       PARTICULATE LOADING
         PLANT                 : HRC-4-----FILTER----TOTAL
         PLANT SITE            : NORFOLK , VA
         SAMPLING LOCATION     : BAGHOUSE INLET
         TEST #                : HR-C-4
         DATE                  : 10/1/84
         TEST PERIOD           :
1300-1754 STOPPED 1536-1609 FOR FILTER AND SG CHANGE


      PARAMETER            Filter              Total
      ---------          ----------            -----

      Total Grams         0.5958000          5.6417010
      Grams/dscf          0.0008630          0.0081717
      Grams/acf           0.0003319          0.0031427
      Grains/dscf         0.0133159          0.1260894
      Grains/acf          0.0051211          0.0484922
      Grams/dscm          0.0304720          0.2885429
      Grams/acm           0.0117191          0.1109695
      Pounds/dscf         0.0000019          0.0000180
      Pounds/acf          0.0000007          0.0000069
      Pounds/Hr           0.0109671          0.1038492
      Kilograms/Hr        0.0049747          0.0471057
```

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RADIAN SOURCE TEST
EPA METHOD 5
PARTICULATE LOADING

PLANT : HRC-4----3M----1M
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : BAGHOUSE INLET
TEST # : HR-C-4
DATE : 10/1/84
TEST PERIOD :
1300-1754 STOPPED 1536-1609 FOR FILTER AND SG CHANGE

PARAMETER	3 Micron Cyclone	1 Micron Cyclone
Total Grams	1.3820000	0.0810000
Grams/dscf	0.0020018	0.0001173
Grams/acf	0.0007698	0.0000451
Grains/dscf	0.0308871	0.0018103
Grains/acf	0.0118787	0.0006962
Grams/dscm	0.0706819	0.0041427
Grams/acm	0.0271833	0.0015932
Pounds/dscf	0.0000044	0.0000003
Pounds/acf	0.0000017	0.0000001
Pounds/Hr	0.0254391	0.0014910
Kiloqrams/Hr	0.0115391	0.0006763

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```
          RADIAN SOURCE TEST
          EPA METHOD 5
       PARTICULATE LOADING
        PLANT                 : HRC-4------>1----PROBE+10M
        PLANT SITE            : NORFOLK , VA
        SAMPLING LOCATION     : BAGHOUSE INLET
        TEST #                : HR-C-4
        DATE                  : 10/1/84
        TEST PERIOD           :
1300-1754 STOPPED 1536-1609 FOR FILTER AND SG CHANGE


          PARAMETER                              10 Micron Cyclone
          ---------                              -----

          Total Grams                            3.5379000
          Grams/dscf                             0.0051245
          Grams/acf                              0.0019708
          Grains/dscf                            0.0790704
          Grains/acf                             0.0304094
          Grams/dscm                             0.1809447
          Grams/acm                              0.0695888
          Pounds/dscf                            0.0000113
          Pounds/acf                             0.0000043
          Pounds/Hr                              0.0651236
          Kilograms/Hr                           0.0295399


                              Program Revision:  1/16/84
```

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT :
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : SCRUBBER OUTLET
TEST # : HR-A-4
DATE : 10/01/84
TEST PERIOD : 1300-1730 STOPPED 1318-1328 DUE TO UPSET

PARAMETER	VALUE
Sampling time (min.)	260
Barometric Pressure (in.Hg)	29.95
Sampling nozzle diameter (in.)	.991
Meter Volume (cu.ft.)	999.5501
Meter Pressure (in.H20)	1.9
Meter Temperature (F)	85.81579
Stack dimension (sq.in.)	1734.949
Stack Static Pressure (in.H20)	.03
Stack Moisture Collected (gm)	450.5
Absolute stack pressure(in Hg)	29.95221
Average stack temperature (F)	166.8947
Percent CO2	2.98
Percent O2	17.52
Percent N2	79.5
Delps Subroutine result	5.638799
DGM Factor	.988
Pitot Constant	.84

```
   RADIAN SOURCE TEST
   EPA METHODS 2-5
   FINAL RESULTS
PLANT                :
PLANT SITE           : NORFOLK , VA
SAMPLING LOCATION    : SCRUBBER OUTLET
TEST #               : HR-A-4
DATE                 : 10/01/84
TEST PERIOD          : 1300-1730 STOPPED 1318-1328 DUE TO UPSET

    PARAMETER                   RESULT
    ---------                   ------

    Vm(dscf)                    960.7395
    Vm(dscm)                    27.20814
    Vw gas(scf)                 21.24108
    Vw gas (scm)                .6015473
    % moisture                  2.163085
    Md                          .9783691
    MWd                         29.1776
    MW                          28.93582
    Vs(fpm)                     825.2778
    Vs (mpm)                    251.6091
    Flow(acfm)                  9943.159
    Flow(acmm)                  281.5903
    Flow(dscfm)                 8202.264
    Flow(dscmm)                 232.2881
    % I                         101.392
    % EA                        505.1905


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```

```
        RADIAN SOURCE TEST
        EPA METHOD 5
   PARTICULATE LOADING
     PLANT                  : HRA 4--FILTER---TOTAL
     PLANT SITE             : NORFOLK , VA
     SAMPLING LOCATION      : SCRUBBER OUTLET
     TEST #                 : HR-A-4
     DATE                   : 10/01/84
     TEST PERIOD            : 1300-1730 STOPPED 1318-1328 DUE TO UPSET

PARAMETER               Filter              Total
---------             -----------           -----

Total Grams            0.1490000           0.1670000
Grams/dscf             0.0001551           0.0001738
Grams/acf              0.0001279           0.0001434
Grains/dscf            0.0023930           0.0026821
Grains/acf             0.0019740           0.0022125
Grams/dscm             0.0054762           0.0061377
Grams/acm              0.0045174           0.0050631
Pounds/dscf            0.0000003           0.0000004
Pounds/acf             0.0000003           0.0000003
Pounds/Hr              0.1682962           0.1886272
Kilograms/Hr           0.0763386           0.08[illegible]5607




                                             Program Revision:1/16/84
        RADIAN SOURCE TEST
        EPA METHOD 5
     PARTICULATE LOADING
      PLANT                  : HRA-4--- PROBE RINSE ALSO>10M
      PLANT SITE             : NORFOLK , VA
      SAMPLING LOCATION      : SCRUBBER OUTLET
      TEST #                 : HR-A-4
      DATE                   : 10/01/84
      TEST PERIOD            : 1300-1730 STOPPED 1318-1328 DUE TO UPSET

PARAMETER          10 Micron Cyclone       10 Micron Cyclone
---------          -----------             -----

Total Grams           0.0147000               0.0147000
Grams/dscf            0.0000153               0.0000153
Grams/acf             0.0000126               0.0000126
Grains/dscf           0.0002361               0.0002361
Grains/acf            0.0001948               0.0001948
Grams/dscm            0.0005403               0.0005403
Grams/acm             0.0004457               0.0004457
Pounds/dscf           0.0000000               0.0000000
Pounds/acf            0.0000000               0.0000000
Pounds/Hr             0.0166037               0.0166037
Kilograms/Hr          0.0075314               0.0075314

     * BACK-HALF IMPINGER ANALYSIS WAS NOT REQUIRED



                                            Program Revision:1/16/84
```

```
                  RADIAN  SOURCE  TEST
                  EPA  METHOD  2-5
                   (RAW  DATA)
                PLANT                : HRC-6
                PLANT SITE           : NORFOLK , VA
                SAMPLING LOCATION    : BAGHOUSE INLET
                TEST #               : HR-C-6
                DATE                 : 10/03/84
                TEST PERIOD          :
1300-2040 STOPPED 1408-1448 FOR UPSET STOPPED 1710-1755 FOR FILTER AND SG
HANGE


                    PARAMETER                                  VALUE
                    ---------                                  -----

                    Sampling time (min.)                        375
                    Barometric Pressure (in.Hg)                 30.05
                    Sampling nozzle diameter (in.)              1.225
                    Meter Volume (cu.ft.)                       1014.584
                    Meter Pressure (in.H2O)                     1.011539
                    Meter Temperature (F)                       83.98001
                    Stack dimension (sq.in.)                    53.45629
                    Stack Static Pressure (in.H2O)             -6
                    Stack Moisture Collected (gm)               8952.901
                    Absolute stack pressure(in Hg)              29.60882
                    Average stack temperature (F)               486.1539
                    Percent CO2                                 7.28
                    Percent O2                                  13.86
                    Percent N2                                  78.86
                    Delps Subroutine result                     4.350066
                    DGM Factor                                  .991
                    Pitot Constant                              .84
```

```
          RADIAN SOURCE TEST
          EPA METHODS 2-5
          FINAL RESULTS
        PLANT                 : HRC-6
        PLANT SITE            : NORFOLK , VA
        SAMPLING LOCATION     : BAGHOUSE INLET
        TEST #                : HR-C-6
        DATE                  : 10/03/84
        TEST PERIOD           :
1300-2040 STOPPED 1408-1448 FOR UPSET STOPPED 1710-1755 FOR FILTER AND SG
HANGE

          PARAMETER                RESULT
          ---------                ------

          Vm(dscf)                 982.5827
          Vm(dscm)                 27.82674
          Vw gas(scf)              422.1293
          Vw gas (scm)             11.9547
          % moisture               30.05095
          Md                       .6994905
          MWd                      29.7192
          MW                       26.19747
          Vs(fpm)                  672.9791
          Vs (mpm)                 205.1766
          Flow(acfm)               249.8262
          Flow(acmm)               7.075076
          Flow(dscfm)              96.50534
          Flow(dscmm)              2.733031
          % I                      123.2193
          % EA                     199.1654
```

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```
              RADIAN  SOURCE  TEST
              EPA  METHOD  5
          PARTICULATE  LOADING
            PLANT                : HRC-6------FILTER-----TOTAL
            PLANT SITE           : NORFOLK , VA
            SAMPLING LOCATION    : BAGHOUSE INLET
            TEST #               : HR-C-6
            DATE                 : 10/03/84
            TEST PERIOD          :
1300-2040 STOPPED 1408-1448 FOR UPSET STOPPED 1710-1755 FOR FILTER AND SG
HANGE


        PARAMETER            Filter             Total
        ---------          ----------           -----

        Total Grams          0.6896000          9.2289000
        Grams/dscf           0.0007018          0.0093925
        Grams/acf            0.0002711          0.0036282
        Grains/dscf          0.0108291          0.1449262
        Grains/acf           0.0041832          0.0559835
        Grams/dscm           0.0247814          0.3316489
        Grams/acm            0.0095728          0.1281127
        Pounds/dscf          0.0000015          0.0000207
        Pounds/acf           0.0000006          0.0000080
        Pounds/Hr            0.0089606          0.1199201
        Kilograms/Hr         0.0040645          0.0543954


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```

PARAMETER	3 Micron Cyclone	1 Micron Cyclone
Total Grams	2.7680000	0.3004000
Grams/dscf	0.0028171	0.0003057
Grams/acf	0.0010882	0.0001181
Grains/dscf	0.0434673	0.0047173
Grains/acf	0.0167910	0.0018223
Grams/dscm	0.0994706	0.0107951
Grams/acm	0.0384245	0.0041701
Pounds/dscf	0.0000062	0.0000007
Pounds/acf	0.0000024	0.0000003
Pounds/Hr	0.0359673	0.0039034
Kilograms/Hr	0.0163147	0.0017706

PARAMETER	10 Micron Cyclone
Total Grams	5.4421000
Grams/dscf	0.0055386
Grams/acf	0.0021395
Grains/dscf	0.0854601
Grains/acf	0.0330124
Grams/dscm	0.1955668
Grams/acm	0.0755455
Pounds/dscf	0.0000122
Pounds/acf	0.0000047
Pounds/Hr	0.0707145
Kilograms/Hr	0.0320759

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RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : HRD-6
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : BAGHOUSE OUTLET
TEST # : HRD-6-CORRECTED FOR .07 LEAK RATE
DATE : 10/03/84
TEST PERIOD :

PARAMETER	VALUE
Sampling time (min.)	360
Barometric Pressure (in.Hg)	30.05
Sampling nozzle diameter (in.)	1.232
Meter Volume (cu.ft.)	973.765
Meter Pressure (in.H2O)	.9
Meter Temperature (F)	90.875
Stack dimension (sq.in.)	53.45629
Stack Static Pressure (in.H2O)	-10.2
Stack Moisture Collected (gm)	7634.1
Absolute stack pressure(in Hg)	29.3
Average stack temperature (F)	272.625
Percent CO2	6.06
Percent O2	14.51
Percent N2	79.43
Delps Subroutine result	4.268841
DGM Factor	.988
Pitot Constant	.84

```
            RADIAN SOURCE TEST
            EPA METHODS 2-5
            FINAL RESULTS
          PLANT               : HRD-6
          PLANT SITE          : NORFOLK , VA
          SAMPLING LOCATION   : BAGHOUSE OUTLET
          TEST #              : HRD-6-CORRECTED FOR .07 LEAK RATE FOUND
          DATE                : 10/03/84
          TEST PERIOD         :
1300-1940 STOPPED 1412-1452 PLANT UPSET PORT CAP AT INLET LEFT OFF 1740
AY NOT BE A GOOD TEST

            PARAMETER                  RESULT
            ----------                 ------

            Vm(dscf)                    928.1758
            Vm(dscm)                    26.28594
            Vw gas(scf)                 359.9478
            Vw gas (scm)                10.19372
            % moisture                  27.94358
            Md                          .7205642
            MWd                         29.55
            MW                          26.32252
            Vs(fpm)                     662.3055
            Vs (mpm)                    201.9224
            Flow(acfm)                  245.8639
            Flow(acmm)                  6.962864
            Flow(dscfm)                 125.0333
            Flow(dscmm)                 3.540942
            % I                         92.52201
            % EA                        224.6297



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```

```
                    RADIAN SOURCE TEST
                    EPA METHOD 5
                 PARTICULATE LOADING
                   PLANT              : HRD-6-----FILTER-----TOTAL
                   PLANT SITE         : NORFOLK , VA
                   SAMPLING LOCATION  : BAGHOUSE OUTLET
                   TEST #             : HRD-6-CORRECTED FOR .07 LEAK RATE FOUND AT
                   DATE               : 10/03/84
                   TEST PERIOD        :
1300-1940 STOPPED 1412-1452 PLANT UPSET PORT CAP AT INLET LEFT OFF 1740        M
AY NOT BE A GOOD TEST


      PARAMETER              Filter              Total
      ---------            -----------           -----

      Total Grams          0.0113000           0.0532000
      Grams/dscf           0.0000122           0.0000573
      Grams/acf            0.0000062           0.0000291
      Grains/dscf          0.0001879           0.0008844
      Grains/acf           0.0000955           0.0004498
      Grams/dscm           0.0004299           0.0020239
      Grams/acm            0.0002186           0.0010292
      Pounds/dscf          0.0000000           0.0000001
      Pounds/acf           0.0000000           0.0000001
      Pounds/Hr            0.0002014           0.0009481
      Kilograms/Hr         0.0000913           0.0004301


                                                     Program Revision:1/16/84
```

```
        RADIAN  SOURCE  TEST
        EPA  METHOD  5
     PARTICULATE  LOADING
         PLANT                  : HRD-6---PROBE RINSE ALSO>10M
         PLANT SITE             : NORFOLK , VA
         SAMPLING LOCATION      : BAGHOUSE OUTLET
         TEST #                 : HRD-6-CORRECTED FOR .07 LEAK RATE FOUND AT
         DATE                   : 10/03/84
         TEST PERIOD            :
1300-1940 STOPPED 1412-1452 PLANT UPSET PORT CAP AT INLET LEFT OFF 1740        M
AY NOT BE A GOOD TEST


      PARAMETER           10 Micron Cyclone
      ---------           -----------

      Total Grams          0.0248000
      Grams/dscf           0.0000267
      Grams/acf            0.0000136
      Grains/dscf          0.0004123
      Grains/acf           0.0002097
      Grams/dscm           0.0009435
      Grams/acm            0.0004798
      Pounds/dscf          0.0000001
      Pounds/acf           0.0000000
      Pounds/Hr            0.0004420
      Kilograms/Hr         0.0002005

        * BACK-HALF IMPINGER ANALYSIS WAS NOT REQUIRED




                                          Program Revision:1/16/84
```

```
            RADIAN SOURCE TEST
            EPA METHOD 2-5
             (RAW DATA)
         PLANT                   :
         PLANT SITE              : NORFOLK , VA
         SAMPLING LOCATION       : BAGHOUSE INLET
         TEST #                  : HR-C-7
         DATE                    : 10/04/84
         TEST PERIOD             :
1315-2002 STOPPED 1715-1743 FOR FILTER AND SG CHANGE

            PARAMETER                                VALUE
            ---------                                -----

            Sampling time (min.)                      379
            Barometric Pressure (in.Hg)               30.24
            Sampling nozzle diameter (in.)            1.225
            Meter Volume (cu.ft.)                     999.4379
            Meter Pressure (in.H2O)                   .988
            Meter Temperature (F)                     86.58
            Stack dimension (sq.in.)                  53.45629
            Stack Static Pressure (in.H2O)           -6
            Stack Moisture Collected (gm)             8517.401
            Absolute stack pressure(in Hg)            29.79882
            Average stack temperature (F)             448.76
            Percent CO2                               6.31
            Percent O2                                15.3
            Percent N2                                78.39
            Delps Subroutine result                   4.263238
            DGM Factor                                .991
            Pitot Constant                            .84
```

```
        RADIAN SOURCE TEST
        EPA METHODS 2-5
        FINAL RESULTS
      PLANT                   : HRC-7
      PLANT SITE              : NORFOLK , VA
      SAMPLING LOCATION       : BAGHOUSE INLET
      TEST #                  : HR-C-7
      DATE                    : 10/04/84
      TEST PERIOD             :
1315-2002 STOPPED 1715-1743 FOR FILTER AND SG CHANGE


        PARAMETER                    RESULT
        ---------                    ------

        Vm(dscf)                      969.3306
        Vm(dscm)                      27.45144
        Vw gas(scf)                   401.5955
        Vw gas (scm)                  11.37318
        % moisture                    29.29374
        Md                            .7070627
        MWd                           29.6216
        MW                            26.2172
        Vs(fpm)                       657.1928
        Vs (mpm)                      200.3637
        Flow(acfm)                    243.9659
        Flow(acmm)                    6.909114
        Flow(dscfm)                   99.81809
        Flow(dscmm)                   2.826848
        % I                           116.2828
        % EA                          283.5981
```

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```
            RADIAN SOURCE TEST
             EPA METHOD 5
        PARTICULATE LOADING
          PLANT                  : HRC-7-----FILTER-----TOTAL
          PLANT SITE             : NORFOLK , VA
          SAMPLING LOCATION      : BAGHOUSE INLET
          TEST #                 : HR-C-7
          DATE                   : 10/04/84
          TEST PERIOD            :
1315-2002 STOPPED 1715-1743 FOR FILTER AND SG CHANGE

     PARAMETER            Filter            Total
     ---------          ----------          -----

     Total Grams        0.7012000        10.1498000
     Grams/dscf         0.0007234         0.0104709
     Grams/acf          0.0002960         0.0042842
     Grains/dscf        0.0111618         0.1615666
     Grains/acf         0.0045668         0.0661046
     Grams/dscm         0.0255428         0.3697288
     Grams/acm          0.0104508         0.1512737
     Pounds/dscf        0.0000016         0.0000231
     Pounds/acf         0.0000007         0.0000094
     Pounds/Hr          0.0095530         0.1382785
     Kilograms/Hr       0.0043332         0.0627227
```

Program Revision: 1/16/84

```
                    RADIAN SOURCE TEST
                     EPA METHOD 5
                 PARTICULATE LOADING
                  PLANT                      : HRC-7----3M-----1M
                  PLANT SITE                 : NORFOLK , VA
                  SAMPLING LOCATION          : BAGHOUSE INLET
                  TEST #                     : HR-C-7
                  DATE                       : 10/04/84
                  TEST PERIOD                :
1315-2002 STOPPED 1715-1743 FOR FILTER AND SG CHANGE

               PARAMETER          3 Micron Cyclone          1 Micron Cyclone
               ---------          ----------------          ------

               Total Grams            3.2277000                 0.4922000
               Grams/dscf             0.0033298                 0.0005078
               Grams/acf              0.0013624                 0.0002078
               Grains/dscf            0.0513792                 0.0078349
               Grains/acf             0.0210217                 0.0032056
               Grams/dscm             0.1175761                 0.0179295
               Grams/acm              0.0481060                 0.0073358
               Pounds/dscf            0.0000073                 0.0000011
               Pounds/acf             0.0000030                 0.0000005
               Pounds/Hr              0.0439734                 0.0067056
               Kilograms/Hr           0.0199462                 0.0030416



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```

```
         RADIAN SOURCE TEST
         EPA METHOD 5
      PARTICULATE LOADING
        PLANT                    : HRC-7---->1M------PROBE+10M
        PLANT SITE               : NORFOLK , VA
        SAMPLING LOCATION        : BAGHOUSE INLET
        TEST #                   : HR-C-7
        DATE                     : 10/04/84
        TEST PERIOD              :
1315-2002 STOPPED 1715-1743 FOR FILTER AND SG CHANGE

     PARAMETER                              10 Micron Cyclone
     ---------                               ---------

     Total Grams                              5.6971000
     Grams/dscf                               0.0058774
     Grams/acf                                0.0024047
     Grains/dscf                              0.0906876
     Grains/acf                               0.0371046
     Grams/dscm                               0.2075294
     Grams/acm                                0.0849102
     Pounds/dscf                              0.0000130
     Pounds/acf                               0.0000053
     Pounds/Hr                                0.0776160
     Kilograms/Hr                             0.0352064



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      RADIAN SOURCE TEST
      EPA METHOD 2-5
      (RAW DATA)
    PLANT                :
    PLANT SITE           : NORFOLK , VA
    SAMPLING LOCATION    : BAGHOUSE OUTLET
    TEST #               : HR-D-7
    DATE                 : 10/04/84
    TEST PERIOD          : 1320-1950

  PARAMETER
  ---------                                    VALUE
                                               -----

  Sampling time (min.)                          390
  Barometric Pressure (in.Hg)                   30.24
  Sampling nozzle diameter (in.)                1.232
  Meter Volume (cu.ft.)                         1112.2
  Meter Pressure (in.H20)                       .9
  Meter Temperature (F)                         110.3
  Stack dimension (sq.in.)                      53.45629
  Stack Static Pressure (in.H20)               -11
  Stack Moisture Collected (gm)                 8676.401
  Absolute stack pressure(in Hg)                29.43118
  Average stack temperature (F)                 302.6539
  Percent C02                                   6.26
  Percent 02                                    14.58
  Percent N2                                    79.16001
  Delps Subroutine result                       4.68111
  DGM Factor                                    .988
  Pitot Constant                                .84
```

```
   RADIAN SOURCE TEST
   EPA METHODS 2-5
   FINAL RESULTS
PLANT                : HRD-7
PLANT SITE           : NORFOLK , VA
SAMPLING LOCATION    : BAGHOUSE OUTLET
TEST #               : HR-D-7
DATE                 : 10/04/84
TEST PERIOD          : 1320-1950

   PARAMETER                  RESULT
   ---------                  ------

   Vm(dscf)                    1030.481
   Vm(dscm)                    29.18322
   Vw gas(scf)                 409.0924
   Vw gas (scm)                11.5855
   % moisture                  28.41761
   Md                          .7158239
   MWd                         29.5848
   MW                          26.29268
   Vs(fpm)                     725.0595
   Vs (mpm)                    221.0547
   Flow(acfm)                  269.1596
   Flow(acmm)                  7.622601
   Flow(dscfm)                 131.2105
   Flow(dscmm)                 3.715881
   % I                         90.35447
   % EA                        230.7604
```

Program Revision: 1/16/84

```
       RADIAN  SOURCE  TEST
       EPA  METHOD  5
    PARTICULATE  LOADING
     PLANT                  : HRD-7----FILTER-----TOTAL
     PLANT SITE             : NORFOLK , VA
     SAMPLING LOCATION      : BAGHOUSE OUTLET
     TEST #                 : HR-D-7
     DATE                   : 10/04/84
     TEST PERIOD            : 1320-1950

 PARAMETER              Filter              Total
 ---------           -----------            -----

 Total Grams          0.0073000           0.0559000
 Grams/dscf           0.0000071           0.0000542
 Grams/acf            0.0000035           0.0000264
 Grains/dscf          0.0001093           0.0008370
 Grains/acf           0.0000533           0.0004080
 Grams/dscm           0.0002501           0.0019154
 Grams/acm            0.0001219           0.0009337
 Pounds/dscf          0.0000000           0.0000001
 Pounds/acf           0.0000000           0.0000001
 Pounds/Hr            0.0001230           0.0009417
 Kilograms/Hr         0.0000558           0.0004271



                          Program Revision:  1/16/84
```

```
        RADIAN  SOURCE  TEST
        EPA  METHOD  5
     PARTICULATE  LOADING
      PLANT                 : HRD-7---PROBE RINSE--ALSO>10M
      PLANT SITE            : NORFOLK , VA
      SAMPLING LOCATION     : BAGHOUSE OUTLET
      TEST #                : HR-D-7
      DATE                  : 10/04/84
      TEST PERIOD           : 1320-1950

 PARAMETER             10 Micron
 ---------             ----------

 Total Grams            0.0394000
 Grams/dscf             0.0000382
 Grams/acf              0.0000186
 Grains/dscf            0.0005900
 Grains/acf             0.0002876
 Grams/dscm             0.0013501
 Grams/acm              0.0006581
 Pounds/dscf            0.0000001
 Pounds/acf             0.0000000
 Pounds/Hr              0.0006637
 Kilograms/Hr           0.0003011

     * BACK-HALF IMPINGER ANALYSIS WAS NOT REQUIRED
```

Program Revision: 1/16/84

```
              RADIAN SOURCE TEST
              EPA METHOD 2-5
              (RAW DATA)
           PLANT                  : HRC-8
           PLANT SITE             : NORFOLK , VA
           SAMPLING LOCATION      : BAGHOUSE INLET
           TEST #                 : HR-C-8
           DATE                   : 10/05/84
           TEST PERIOD            :
1245-1945 STOPPED 1600-1650 FOR FILTER AND SG CHANGE 1705-1730 FOR FILTER
HECK OK!!

             PARAMETER                                 VALUE
             ---------                                 -----

             Sampling time (min.)                      345
             Barometric Pressure (in.Hg)               30.36
             Sampling nozzle diameter (in.)            1.225
             Meter Volume (cu.ft.)                     888.469
             Meter Pressure (in.H2O)                   .973913
             Meter Temperature (F)                     90.15
             Stack dimension (sq.in.)                  53.45629
             Stack Static Pressure (in.H2O)           -6
             Stack Moisture Collected (gm)             8321.8
             Absolute stack pressure(in Hg)            29.91882
             Average stack temperature (F)             439.4348
             Percent CO2                               6.92
             Percent O2                                13.68
             Percent N2                                79.4
             Delps Subroutine result                   4.241308
             DGM Factor                                .991
             Pitot Constant                            .84
```

```
                 RADIAN SOURCE TEST
                 EPA METHODS 2-5
                 FINAL RESULTS
              PLANT                 : HRC-8
              PLANT SITE            : NORFOLK , VA
              SAMPLING LOCATION     : BAGHOUSE INLET
              TEST #                : HR-C-8
              DATE                  : 10/05/84
              TEST PERIOD           :
  1245-1945 STOPPED 1600-1650 FOR FILTER AND SG CHANGE 1705-1730 FOR FILTER
 CHECK OK!!

                 PARAMETER                    RESULT
                 ---------                    ------

                 Vm(dscf)                      859.4727
                 Vm(dscm)                      24.34027
                 Vw gas(scf)                   392.3729
                 Vw gas (scm)                  11.112
                 % moisture                    31.34355
                 Md                            .6865645
                 MWd                           29.6544
                 MW                            26.0015
                 Vs(fpm)                       655.2005
                 Vs (mpm)                      199.7563
                 Flow(acfm)                    243.2263
                 Flow(acmm)                    6.88817
                 Flow(dscfm)                   98.0255
                 Flow(dscmm)                   2.776082
                 % I                           115.3363
                 % EA                          187.8708
```

Program Revision: 1/16/84

```
                 RADIAN SOURCE TEST
                 EPA METHOD 5
              PARTICULATE LOADING
               PLANT                  : HRC-8------FILTER----TOTAL
               PLANT SITE             : NORFOLK , VA
               SAMPLING LOCATION      : BAGHOUSE INLET
               TEST #                 : HR-C-8
               DATE                   : 10/05/84
               TEST PERIOD            :
 1245-1945 STOPPED 1600-1650 FOR FILTER AND SG CHANGE 1705-1730 FOR FILTER
CHECK OK!!

            PARAMETER             Filter             Total
            ---------           -----------          -----

            Total Grams          0.8114000           9.4205000
            Grams/dscf           0.0009441           0.0109608
            Grams/acf            0.0003805           0.0044174
            Grains/dscf          0.0145670           0.1691250
            Grains/acf           0.0058708           0.0681610
            Grams/dscm           0.0333350           0.3870255
            Grams/acm            0.0134347           0.1559797
            Pounds/dscf          0.0000021           0.0000242
            Pounds/acf           0.0000008           0.0000097
            Pounds/Hr            0.0122434           0.1421480
            Kilograms/Hr         0.0055536           0.0644779
```

Program Revision: 1/16/84

```
                    RADIAN  SOURCE  TEST
                     EPA  METHOD  5
                  PARTICULATE  LOADING
                   PLANT                   : HRC-8----3M----1M
                   PLANT SITE              : NORFOLK , VA
                   SAMPI ING LOCATION      : BAGHOUSE INLET
                   TEST #                  : HR-C-8
                   DATE                    : 10/05/84
                   TEST PERIOD             :
 1245-1945 STOPPED 1600-1650 FOR FILTER AND SG CHANGE 1705-1730 FOR FILTER
CHECK OK!!

              PARAMETER            3 Micron Cyclone      1 Micron Cyclone
              ---------            -----------                -----

              Total Grams            2.6959000              0.4880000
              Grams/dscf             0.0031367              0.0005678
              Grams/acf              0.0012642              0.0002288
              Grains/dscf            0.0483991              0.0087610
              Grains/acf             0.0195059              0.0035309
              Grams/dscm             0.1107566              0.0200487
              Grams/acm              0.0446373              0.0080800
              Pounds/dscf            0.0000069              0.0000013
              Pounds/acf             0.0000028              0.0000005
              Pounds/Hr              0.0406790              0.0073635
              Kiloqrams/Hr           0.0184519              0.0033401


                                  Program Revision:  1/16/84
```

```
            RADIAN  SOURCE  TEST
            EPA  METHOD  5
          PARTICULATE  LOADING
           PLANT                :  HRC-8------>1M-----PROBE+10M
           PLANT SITE           :  NORFOLK , VA
           SAMPLING LOCATION    :  BAGHOUSE INLET
           TEST #               :  HR-C-8
           DATE                 :  10/05/84
           TEST PERIOD          :
 1245-1945 STOPPED 1600-1650 FOR FILTER AND SG CHANGE 1705-1730 FOR FILTER
CHECK OK!!

           PARAMETER                          10 Micron Cyclone
           ---------                             -----

           Total Grams                           5.3617000
           Grams/dscf                            0.0062384
           Grams/acf                             0.0025142
           Grains/dscf                           0.0962579
           Grains/acf                            0.0387940
           Grams/dscm                            0.2202765
           Grams/acm                             0.0887762
           Pounds/dscf                           0.0000138
           Pounds/acf                            0.0000055
           Pounds/Hr                             0.0809039
           Kilograms/Hr                          0.0366978
```

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RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : HRD-8
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : BAGHOUSE OUTLET
TEST # : HR-D-8
DATE : 10/05/84
TEST PERIOD : 1240-1910

PARAMETER	VALUE
Sampling time (min.)	390
Barometric Pressure (in.Hg)	30.35
Sampling nozzle diameter (in.)	1.232
Meter Volume (cu.ft.)	1089.77
Meter Pressure (in.H20)	.9
Meter Temperature (F)	105.7308
Stack dimension (sq.in.)	53.45629
Stack Static Pressure (in.H20)	13.1
Stack Moisture Collected (gm)	9314
Absolute stack pressure(in Hg)	29.38677
Average stack temperature (F)	283.9231
Percent CO2	6.14
Percent O2	15.11
Percent N2	78.75
Delps Subroutine result	4.509568
DGM Factor	.988
Pitot Constant	.84

```
     RADIAN  SOURCE  TEST
     EPA METHODS 2-5
     FINAL  RESULTS
PLANT                  : HRD-8
PLANT SITE             : NORFOLK , VA
SAMPLING LOCATION      : BAGHOUSE OUTLET
TEST #                 : HR-D-8
DATE                   : 10/05/84
TEST PERIOD            : 1240-1910

    PARAMETER                  RESULT
    ---------                  ------

    Vm(dscf)                    1021.548
    Vm(dscm)                    28.93025
    Vw gas(scf)                 439.1551
    Vw gas (scm)                12.43687
    % moisture                  30.06463
    Md                          .6993537
    MWd                         29.5868
    MW                          26.10327
    Vs(fpm)                     701.5482
    Vs (mpm)                    213.8867
    Flow(acfm)                  260.4317
    Flow(acmm)                  7.375426
    Flow(dscfm)                 126.9658
    Flow(dscmm)                 3.595671
    % I                         92.56578
    % EA                        266.0212
```

Program Revision: 1/16/84

RADIAN SOURCE TEST
EPA METHOD 5
PARTICULATE LOADING

PLANT : HRD-8---FILTER----TOTAL
PLANT SITE : NORFOLK , VA
SAMPLING LOCATION : BAGHOUSE OUTLET
TEST # : HR-D-8
DATE : 10/05/84
TEST PERIOD : 1240-1910

PARAMETER	Filter	Total
Total Grams	0.0042000	0.1376000
Grams/dscf	0.0000041	0.0001347
Grams/acf	0.0000020	0.0000657
Grains/dscf	0.0000634	0.0020784
Grains/acf	0.0000309	0.0010133
Grams/dscm	0.0001452	0.0047562
Grams/acm	0.0000708	0.0023187
Pounds/dscf	0.0000000	0.0000003
Pounds/acf	0.0000000	0.0000001
Pounds/Hr	0.0000691	0.0022626
Kilograms/Hr	0.0000313	0.0010263

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```
           RADIAN SOURCE TEST
           EPA METHOD 5
        PARTICULATE LOADING
          PLANT                 : HRD-8---PROBE RINSE ALSO>10M
          PLANT SITE            : NORFOLK , VA
          SAMPLING LOCATION     : BAGHOUSE OUTLET
          TEST #                : HR-D-8
          DATE                  : 10/05/84
          TEST PERIOD           : 1240-1910

     PARAMETER            10 Micron
     ---------            ---------

     Total Grams          0.1313000
     Grams/dscf           0.0001285
     Grams/acf            0.0000627
     Grains/dscf          0.0019832
     Grains/acf           0.0009669
     Grams/dscm           0.0045384
     Grams/acm            0.0022126
     Pounds/dscf          0.0000003
     Pounds/acf           0.0000001
     Pounds/Hr            0.0021590
     Kilograms/Hr         0.0009793

        * BACK-HALF IMPINGER ANALYSIS WAS NOT REQUIRED
```

Program Revision: 1/16/84

APPENDIX C

CONTINUOUS EMISSIONS MONITORING DATA

Appendix C contains tabular summaries of the continuous monitoring data for each test run.

TABLE C.1 CONTINUOUS MONITORING DATA--RUN 02

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1200	12.6	1639.2	7.0	455.7	180.1	36.0
1205	12.5	1480.8	7.0	458.7	182.2	36.8
1210	12.3	1335.7	7.1	446.3	183.5	32.7
1215	12.0	1209.0	7.4	458.6	186.5	18.5
1220	11.7	1069.7	7.7	470.4	188.4	32.4
1225	11.9	1048.2	7.4	441.3	189.1	35.4
1230	12.1	1040.9	7.3	421.4	191.3	29.5
1235	12.2	950.9	7.2	481.5	179.7	29.4
1240	11.8	1064.4	7.6	485.4	203.8	32.3
1300	12.3	869.2	7.2	432.7	201.3	31.3
1305	12.6	816.5	7.0	402.5	196.0	36.5
1310	12.9	825.8	6.7	368.9	196.9	22.4
1315	12.6	821.4	6.9	380.6	203.5	41.3
1320	12.1	754.0	7.4	400.3	195.9	34.2
1325	12.0	717.9	7.5	379.3	194.7	38.6
1330	12.0	691.9	7.4	365.0	195.4	
1335	11.7	664.4	7.6	369.5	192.7	
1340	10.7	633.2	8.5	428.5	203.0	
1345	10.8	647.5	8.4	418.5	200.9	
1350	10.1	616.2	9.1	503.7	195.6	
1355	10.1	599.3	9.2	496.4	208.7	10.4
1400	10.3	581.0	9.1	473.8	205.6	9.5
1405	10.1	593.9	9.4	533.6	203.1	10.6
1410	9.9	574.4	9.5	509.4	214.3	10.5
1415	10.3	581.0	9.2	482.8	212.7	7.4
1420	10.4	536.7	9.1	486.6	211.5	30.2
1425	9.8	553.8	9.6	533.9	213.9	32.8
1430	10.0	544.1	7.4	504.5	217.6	17.1
1435	10.0	550.1	9.5	480.4	212.6	32.7
1440	9.6	553.7	9.9	553.6	219.7	35.8
1445	9.4	510.3	10.0	537.1	221.4	31.8
1450	9.3	493.8	10.4	580.1	214.4	30.4
1455	9.3	497.8	10.2	556.8	226.3	13.1
1500	9.5	486.4	10.0	583.1	219.6	33.7
1505	9.7	472.9	9.9	566.8	216.5	34.1
1510	10.1	460.9	9.6	546.0	214.2	32.4
1515	10.3	440.8	9.3	532.6	209.1	30.7
1520	10.5	436.8	9.2	526.4	214.2	39.0
1525	10.7	430.8	8.9	505.4	213.0	34.9
1530	10.6	416.0	8.9	513.2	208.8	32.7
1535	10.5	406.0	9.1	528.3	214.7	42.1
1540	9.4	431.0	10.0	634.9	215.3	44.0
1545	9.8	382.6	9.4	405.6	214.8	27.7
1550	10.2	356.2	9.1	576.0	208.0	10.1
1555	10.3	368.9	8.9	557.6	213.4	31.7
1600	10.4	355.3	8.8	559.6	217.8	32.4
1605	9.9	323.2	9.4	598.1	209.0	29.4
1610	10.6	354.8	8.7	524.3	219.6	14.6
1615	10.5	331.4	8.7	514.5	215.8	
1620	9.0	337.4	10.6	714.7	214.0	31.6
1625	9.1	308.6	10.4	671.9	211.8	34.6
1630	9.6	313.8	9.8	610.9	220.8	34.1
1635	9.3	326.3	10.1	607.7	217.8	34.1
1640	9.6	329.2	9.9	503.4	224.3	36.2
1645	9.5	310.8	10.1	508.0	217.7	35.8
1650	8.8	298.5	10.6	566.5	206.7	31.9
1655	10.1	313.4	9.5	475.6	218.0	34.9
1700	9.7	295.3	9.8	495.9	208.7	38.4
1705	10.9	290.0	8.8	481.4	196.0	11.8
1710	11.4	280.7	8.3	426.7	211.2	31.2
1715	11.4	294.5	8.3	436.1	214.9	31.5
1720	10.5	280.9	9.1	510.0	209.3	20.6
1725	10.1	284.2	9.5	568.6	221.3	32.6
1730	10.4	264.4	9.3	516.9	215.6	32.9
1735	10.5	282.7	9.1	432.7	212.7	17.0
1740	9.6	250.1	10.0	469.5	211.0	32.7
1745	9.6	243.8	9.9	469.6	213.3	33.3
1750	9.1	250.8	10.4	627.4	208.1	30.9
1755	9.0	263.1	10.5	650.5	214.4	31.0
1800	8.8	247.9	10.6	586.9	211.6	36.8
1805	9.7	248.7	9.9	561.3	205.4	26.4
1810	9.7	241.4	10.1	583.5	210.2	26.6
1815	10.0	243.3	9.4	516.6	204.9	33.6
1820	10.4	239.3	9.2	528.4	207.0	27.5
1825	10.8	244.3	8.7	486.4	211.7	29.8
1830	10.3	232.9	9.3	512.7	211.6	35.3
NO. PTS.	76	76	76	76	76	70
MEAN	10.5	526.8	9.0	506.4	207.9	29.5
STD. DEV.	1.1	305.9	1.1	72.7	10.7	8.7

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TABLE C.2 CONTINUOUS MONITORING DATA--RUN 03

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1300	4.5		8.4	323.7		47.3
1305	4.9		7.9	300.8		49.4
1310	4.9		8.0	223.0		52.3
1315	4.9	63696.7	8.0	211.6		7.0
1320	4.9	41319.2	8.3	292.4		52.1
1325	4.7	32427.2	9.0	356.7		39.2
1330	4.7	24030.5	8.5	245.5		51.9
1335	5.0	19879.2	8.1	330.0		50.7
1340	5.2	18119.6	8.1	305.8		11.4
1345	5.2	15789.7	8.1	304.4		51.1
1350	5.2	14191.3	8.4	335.3		53.0
1355	5.3	13074.0	8.3	332.8	82749.9	59.4
1400	4.9	11914.7	9.0	388.5	59992.9	57.5
1405	5.1	10817.3	8.9	354.2	48314.7	67.0
1410	5.5	10290.5	8.2	285.0	39800.0	57.9
1415	5.5	8943.1	8.2	224.3	32459.7	19.0
1420	5.7	8258.7	8.0	303.7	28675.5	53.6
1425	5.7	8456.0	8.3	324.1	27471.4	45.6
1430	5.5	8511.6	8.7	365.9	24829.0	6.0
1435	4.5	8669.5	11.2	600.1	22773.4	64.3
1440	4.2	7692.1	11.4	594.5	18820.8	67.2
1445	3.9	7147.9	11.7	590.5	16582.2	39.3
1450	2.9	11890.1	14.1	1011.2	18720.8	106.1
1455	3.4	8897.2	12.9	786.8	15741.1	88.2
1500	5.3	5259.4	9.3	515.5	13961.5	58.6
1505	6.3	4703.5	8.3	414.2	13592.1	42.6
1510	7.1	4307.3	7.1	314.3	12356.4	38.8
1515	7.3	4050.8	7.1	318.3	11731.1	36.8
1520	7.3	4356.9	7.2	234.1	11890.7	39.4
1525	7.4	3806.6	7.2	337.3	10779.0	38.1
1530	7.8	3957.7	6.7	296.6	10972.2	28.9
1535	7.9	3831.1	6.8	346.0	10633.1	36.0
1540	7.9	3847.0	8.1	375.8	10026.4	34.9
1545	6.3	3363.7	9.3	493.9	8799.2	46.4
1550	6.3	3472.7	9.2	479.6	8403.9	35.0
1555	6.2	3326.2	9.7	506.2	8360.0	38.7
1600	6.7	3350.3	9.2	451.7	8461.3	34.6
1605	7.3	3013.5	7.2	402.4	8185.8	
1610	7.9	2753.8	7.9	375.1	7662.5	32.7
1615	8.1	3022.3	7.7	369.7	7762.7	34.5
1620	7.8	2983.6	8.6	445.1	7313.0	34.7
1625	8.1	2801.1	8.0	395.3	7111.1	39.1
1630	8.5	2710.9	7.7	367.3	6883.5	32.8
1635	8.6	2876.8	8.0	405.1	6991.5	36.2
1640	8.2	2852.6	8.5	419.8	6794.6	14.2
1645	7.7	2420.3	9.2	482.3	6422.3	27.8
1650	8.2	2671.0	8.8	465.1	6344.2	22.6
1655	8.1	2502.2	9.1	493.3	6234.6	32.1
1700	7.9	2280.7	9.6	518.5	6077.3	34.7
1705	8.7	2323.5	8.8	450.2	5873.9	19.4
1710	8.8	2073.5	8.5	433.4	5557.6	30.0
1715	8.9	2264.7	8.7	465.0	5483.9	31.2
1720	8.8	2165.4	9.1	496.7	5086.8	26.7
1725	9.9	1996.3	8.1	365.1	5032.4	26.9
1730	9.9	19425.0	8.4	353.9	5285.0	3.8
1735	10.1	1981.2	7.8	335.8	4726.6	27.7
1740	10.2	1943.9	8.3	370.3	4794.0	29.7
1745	10.0	1850.7	8.5	411.2	4554.4	28.4
1750	10.2	1864.7	8.8	463.0	4518.9	18.6
1755	10.0	1957.7	9.2	481.4	4450.0	33.5
NO. PTS.	60	58	60	60	51	59
MEAN	6.8	11210.4	8.7	404.0	20963.9	39.4
STD. DEV.	1.9	23763.4	1.3	130.9	36609.6	18.2

TABLE C.3 CONTINUOUS MONITORING DATA--RUN 04

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1230	11.7	649.8	7.6	118.2	216.9	252.5
1235	11.8	724.5	7.6	119.5	213.4	266.0
1240	11.2	696.1	8.2	130.9	219.2	221.3
1245	11.4	714.3	8.0	125.6	220.9	216.0
1250	11.1	654.0	8.4	147.3	209.3	196.0
1255	10.6	673.4	8.7	148.5	220.8	176.4
1300	10.6	650.7	9.0	140.9	209.7	166.0
1305	10.4	675.2	8.9	155.5	209.8	155.0
1310	10.4	693.0	9.0	159.8	219.9	166.3
1315	10.4	621.8	9.0	149.4	214.0	149.7
1320	11.0	683.2	8.5	127.5	213.9	130.2
1325	10.3	640.5	9.1	140.6	213.7	130.4
1330	10.5	704.7	8.7	134.7	217.2	129.7
1335	10.6	689.7	8.7	124.4	219.7	126.7
1340	10.6	644.5	8.9	131.3	216.5	113.7
1345	10.8	637.1	8.4	121.2	216.5	107.9
1350	11.4	669.6	7.9	115.7	215.5	109.5
1355	11.6	683.2	7.7	105.8	220.3	100.9
1400	11.6	740.8	7.7	109.6	224.3	101.2
1405	11.6	693.1	7.8	101.2	211.2	96.1
1410	11.8	695.6	7.5	112.7	216.6	90.7
1415	11.9	730.2	7.5	118.1	220.7	93.1
1420	11.7	687.6	7.5	100.0	208.4	83.3
1425	11.2	730.6	7.9	123.5	221.3	89.1
1430	10.9	663.3	8.1	99.6	214.2	86.0
1435	11.3	738.6	7.6	109.4	219.5	89.6
1440	10.7	648.8	8.3	121.9	205.8	37.0
1445	11.1	668.6	7.9	140.2	213.7	28.1
1450	11.0	739.9	7.7	172.2	218.4	78.9
1455	10.8	747.0	8.4	210.8	212.8	73.2
1500	10.8	736.6	8.2	240.1	207.4	72.8
1505	11.0	696.6	8.1	241.5	200.9	68.1
1510	11.4	678.7	7.8	278.4	206.3	69.5
1515	11.5	818.1	7.7	286.4	203.4	72.6
1520	10.5	722.7	8.5	348.2	203.7	65.8
1530	11.0	671.5	7.8	370.2	208.0	61.9
1535	11.1	669.3	5.8	277.3	205.7	42.0
1540	10.9	687.9	5.6	308.3	210.6	48.0
1545	10.5	697.2	5.2	343.9	218.0	42.0
1550	11.5	664.6	6.1	360.0	228.0	48.0
1555	10.7	711.1	5.5	418.5	220.5	6.0
1600	10.6	715.8	5.4	338.9	218.0	6.0
1605	10.6	729.7	5.4	410.6	215.6	6.0
1610	11.6	725.1	6.4	630.0	215.6	6.0
1615	12.0	729.7	7.0	658.4	206.9	6.0
1620	11.4	641.4	7.2	592.5	220.5	42.0
1625	11.1	720.4	7.2	603.4	228.0	42.0
1630	11.8	683.2	7.1	839.2	228.0	42.0
1635	12.8	683.2	7.0	810.9	236.6	30.0
1640	11.8	678.6	7.0	703.1	226.7	12.0
1645	11.8	669.3	6.6	747.2	232.9	18.0
1650	12.0	664.6	6.6	662.4	221.8	30.0
1655	11.1	660.0	6.8	500.7	232.9	30.0
1700	11.5	655.4	6.7	516.7	230.4	30.0
1705	11.4	683.2	6.6	628.8	192.0	30.0
1710	11.5	683.2	6.8	671.8	189.5	30.0
1715	11.5	641.4	7.1	761.6	195.7	36.0
1720	11.5	660.0	6.4	622.0	199.5	36.0
1725	11.5	641.4	6.5	662.9	200.7	30.0
1730	11.9	627.5	6.8	723.3	200.7	30.0
1735	11.5	687.9	6.3	614.7	205.7	30.0
1740	11.9	613.5	7.2	706.0	198.2	30.0
1745	11.8	669.3	7.2	697.8	203.2	30.0
NO. PTS.	63	63	63	63	63	63
MEAN	11.2	685.8	7.5	341.1	214.1	80.0
STD. DEV.	0.5	36.6	1.0	241.2	9.9	62.6

TABLE C.4 CONTINUOUS MONITORING DATA--RUN 06

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1300	11.2	2620.3	8.5	582.3	197.5	142.1
1305	11.1	2682.0	8.6	607.9	194.2	139.6
1310	10.6	2572.7	8.9	649.6	190.3	144.2
1315	11.3	2731.1	9.2	568.1	194.5	171.1
1320	12.1	2618.1	7.8	487.1	194.4	142.3
1325	12.5	2595.0	7.5	445.0	199.7	172.7
1330	12.1	2691.7	7.8	475.9	211.6	172.4
1335	11.7	2800,8	8.3	522.7	213.3	163.2
1340	11.4	2750.7	8.7	550.7	217.4	160.2
1345	9.8	3090.3	10.2	718.4	213.2	164.2
1350	9.6	3068.5	10.4	724.0	207.1	174.4
1355	9.3	2786.5	10.4	711.1	207.4	170.1
1400	7.8	3452.4	12.2	895.5	221.6	143.0
1405	7.1	3392.2	12.6	972.1	203.6	136.5
1410	5.0	3944.1	14.7	1337.2	248.9	143.8
1415	5.3	4152.7	14.0	1258.9	220.3	192.1
1420	6.7	3454.3	12.9	1183.4	233.4	223.8
1425	8.2	2083.3	10.9	879.4	193.8	126.9
1430	6.8	2301.3	12.5	961.1	189.5	154.0
1435	9.9	1713.6	9.9	716.7	182.1	137.0
1440	10.7	1517.1	9.1	636.7	182.3	113.0
1445	11.9	1467.4	8.1	544.8	169.1	117.2
1450	12.9	1464.2	7.3	448.5	159.6	119.9
1455	12.6	1552.5	7.6	472.5	170.3	118.4
1500	13.2	1606.6	7.0	404.2	175.9	120.7
1505	13.0	1576.7	7.5	408.2	164.2	118.5
1510	13.0	1744.4	7.0	379.0	164.4	123.4
1515	13.6	1846.0	6.6	337.5	186.6	123.8
1520	13.7	1918.9	6.7	335.3	201.8	146.1
1525	13.5	2185.9	6.8	347.9	210.7	220.6
1530	11.5	2503.3	9.0	495.4	233.0	155.3
1535	10.5	2518.5	9.7	522.2	262.7	
1540	11.1	1913.8	8.5	493.4	210.7	
1545	11.9	1823.2	8.2	470.6	242.2	
1550	12.1	1753.2	7.4	439.2	202.0	
1555	12.3	2115.5	8.2	466.0	241.6	
1600	14.0	855.7	4.7	326.8	164.0	
1605	12.3	2208.5	8.1	437.8	203.4	
1610	12.0	2166.9	8.2	371.9	204.8	
1615	12.3	2174.0	8.1	514.0	217.5	
1620	11.9	2033.5	8.8	578.7	273.9	
1625	11.4	2024.2	9.0	625.0	260.3	
1630	11.4	1936.6	8.9	601.8	217.4	112.1
1635	11.7	1709.8	8.1	548.0	211.3	122.1
1640	12.4	1861.0	7.5	489.2	223.3	97.0
1645	13.3	1936.9	7.1	430.2	232.5	93.7
1650		1982.7	6.7		217.3	95.0
1655	13.9	2008.3	6.6	399.1	225.8	79.5
1700	13.7	2139.8	6.7	423.7	227.1	109.9
1705	13.3	2141.2	6.9	420.1	227.7	108.7
1710	13.2	2236.6	7.2	445.4	244.7	88.0
1715	12.8	2245.3	7.5	456.9	236.5	87.0
1720	12.4	2243.7	7.9	484.7	233.7	102.8
1725	11.9	2552.3	8.8	555.8	231.3	128.3
1730	11.4	2390.6	8.9	558.5	277.0	113.7
1735	10.9	2548.8	9.4	602.6	240.2	85.6
1740	11.4	2505.0	8.7	530.8	271.3	106.1
1745	11.7	2477.4	8.5	505.1	279.4	128.3
1750	11.8	2547.0	8.4	495.1	283.2	108.0
1755	11.5	2595.5	8.5	515.0	290.6	121.1
1800	11.9	2613.0	8.3	492.7	289.6	90.5
1805	11.6	2679.1	8.8	572.5	287.1	124.4
1810	11.5	2898.1	8.6	545.7	298.5	97.1
1815	10.8	2914.6	9.2	604.0	287.3	126.6
1820	10.7	3194.2	9.5	612.2	258.6	96.0
1825	10.7	3284.6	9.9	640.3	287.0	117.2
1830	10.4	3156.5	9.4	593.0	255.4	142.0
1835	10.8	3207.8	9.4	600.4	293.6	97.5
1840	10.4	3183.7	9.5	607.5	267.3	68.8
1845	10.9	3189.8	9.6	618.3	265.7	137.0
1850	10.1	2767.0	9.6	684.1	267.4	97.7
1855	10.9	2651.9	9.1	635.3	242.4	107.6
1900	11.4	2482.0	8.6	581.1	239.0	114.9
1905	11.7	2439.4	8.5	583.5	239.9	64.4
1910	11.0	2387.3	9.5	690.2	233.1	102.3
1915	11.0	2281.8	8.1	535.2	222.7	114.2
1920	12.4	2438.9	8.0	511.4	236.9	99.7
1925	12.0	2388.1	8.0	529.6	234.0	76.3
1930	11.9	2381.3	8.4	576.2	236.4	71.4
1935	11.2				239.3	87.4
1940	11.7		8.3	556.2	237.9	139.3
1945	11.3		9.1	611.4	238.2	99.6
1950	10.8		9.6	676.8	225.5	100.4
1955	10.8		9.1	666.0	229.3	73.1
2000	11.1	2341.4	8.8	611.5	230.5	87.0
2005	10.8	2459.4	9.3	696.7	232.4	105.4
2010	10.8	2488.2	9.4	685.3	234.5	80.5
2015	11.2	2490.1	9.0	643.8	238.4	95.0
2020	11.1	2502.9	9.3	688.4	241.5	53.9
2025	10.7	2373.9	9.7	737.9	238.2	78.7
2030	10.8	2417.3	9.5	720.9	235.8	88.3
2035	11.2	2457.2	9.2	680.9	233.7	52.4
2040	11.1	2497.5	9.1	672.6	235.7	73.8
NO. PTS.	92	88	92	91	93	82
MEAN	11.3	2421.6	8.8	591.2	227.4	117.6
STD. DEV.	1.7	553.9	1.6	175.8	32.2	33.5

Table C.5 Continuous Monitoring Data--Run 07

TIME	O2 (%V)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1300	11.2	9.0	719.6	56.1	57.9
1305	10.5	9.4	781.6	63.2	85.8
1310	11.8	8.3	661.7	62.4	46.4
1315	11.2	8.5	678.4	59.6	65.7
1320	12.4	7.8	581.2	54.2	48.5
1325	11.9	8.3	633.5	62.9	65.7
1330	11.2	9.0	719.7	50.3	84.9
1335	12.0	8.1	616.3	59.0	72.2
1340	11.7	8.6	685.8	64.4	90.7
1345	11.2	9.0	745.9	62.4	62.1
1350	11.3	8.7	703.7	50.6	76.1
1355	11.7	8.2	653.3	56.4	100.6
1400	11.8	8.3	651.8	58.8	75.4
1405	11.7	8.4	683.8	60.4	89.6
1410	9.9	9.8	859.7	49.6	53.3
1415	11.6	8.4	666.0	57.6	75.4
1420	11.3	8.8	721.2	54.0	44.7
1425	11.3	8.6	708.8	58.8	80.1
1430	11.4	8.5	677.0	56.6	54.6
1435	10.2	9.4	817.2	50.4	79.1
1440	10.9	8.7	758.6	54.4	45.0
1445	11.1	8.8	747.0	49.3	65.5
1450	10.9	8.8	729.9	48.2	40.6
1455	10.0	9.4	859.8	43.4	37.2
1500	10.7	9.0	771.0	44.2	27.1
1505	9.5	10.1	941.6	42.6	56.8
1510	9.8	9.6	900.3	41.3	29.6
1515	11.2	8.3	699.6	42.6	38.2
1520	11.9	8.0	638.2	41.5	27.7
1525	12.0	7.8	654.5	41.7	45.2
1530	11.9	7.7	652.2	41.4	27.1
1535	12.6	7.0	551.7	40.5	26.3
1540	13.0	6.9	565.4	40.2	42.4
1545	12.9	6.8	552.4	40.4	62.8
1550	13.3	6.6	519.0	41.1	77.4
1555	12.5	7.0	583.3	38.2	92.3
1600	13.3	6.5	526.6	177.2	59.1
1605	12.4	7.2	613.8	167.5	48.7
1610	12.9	6.7	559.8	163.8	68.8
1615	12.6	7.1	600.1	172.5	95.6
1620	12.4	7.1	584.7	166.6	49.6
1625	12.4	7.2	604.2	189.3	114.3
1630	13.1	6.7	531.9	195.7	150.9
1635	12.5	7.3	594.0	205.1	93.7
1640	12.6	7.5	599.7	204.2	178.7
1645	12.4	7.3	587.3	198.2	81.7
1650	12.9	7.2	559.1	205.9	190.9
1655	12.9	7.2	569.0	195.1	145.2
1700	13.1	7.1	556.2	206.9	161.4
1705	13.4	6.9	551.8	207.0	160.8
1710	12.6	7.5	608.1	199.4	168.1
1715	13.0	7.2	609.2	206.4	153.4
1720	12.7	7.4	590.9	198.1	169.3
1725	12.7	7.3	599.1	199.5	132.8
1730	12.7	7.5	630.3	202.9	109.6
1735	11.9	7.9	647.1	199.9	99.3
1740	12.4	7.8	649.7	200.2	106.8
1745	12.3	7.9	656.6	197.9	190.7
1750	12.7	7.3	588.3	197.7	70.4
1755	12.5	7.6	635.4	195.5	144.9
NO. PTS.	60	60	60	60	60
MEAN	11.9	8.0	655.7	108.2	84.9
STD. DEV.	0.9	0.9	92.8	70.7	44.8

Table C.6 Continuous Monitoring Data--Run 08

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1240	4.8	2649.8	5.0	305.9	110.0	134.8
1245	4.9	2713.0	4.9	201.5	116.6	136.5
1250	5.0	2709.9	5.0	315.1	116.1	141.9
1255	4.8	2590.6	5.3	350.5	115.4	146.8
1300	4.6	2734.9	5.5	366.1	115.4	138.1
1305	4.7	2559.3	5.5	402.4	118.5	133.0
1310	4.6	2659.5	5.7	399.1	112.6	138.7
1315	4.8	2629.8	5.5	373.0	116.9	130.8
1320	4.3	2810.2	6.3	405.0	113.8	137.0
1325	4.3	2836.0	6.2	487.9	109.0	142.0
1330	4.8	2702.0	5.6	396.0	111.2	132.7
1335	4.6	2755.1	6.0	445.0	111.0	91.2
1340	5.0	2645.8	5.6	392.2	110.0	136.8
1345	4.8	2686.3	5.9	444.4	110.0	138.5
1350	4.7	2751.3	6.1	503.4	109.8	141.7
1355	4.9	2750.3	5.9	457.2	106.8	136.3
1400	5.1	2697.5	5.6	411.3	106.8	134.9
1405	5.0	2747.4	5.8	487.9	110.3	138.4
1410	5.1	2789.1	5.8	466.8	102.3	147.7
1415	4.5	3136.6	6.6	523.5	104.0	151.2
1420	4.8	2923.9	6.2	510.8	103.6	150.1
1425	5.2	2839.1	5.8	433.9	102.9	150.2
1430	5.1	2924.3	6.0	464.5	102.1	145.6
1435	5.3	2962.1	5.9	440.1	100.0	143.6
1440	5.3	2971.2	5.9	454.5	103.8	132.3
1445	5.6	3034.2	5.7	443.0	97.0	142.6
1450	5.6	3020.1	5.8	468.2	97.3	148.6
1455	4.1	2925.4	7.2	506.3	311.9	151.9
1500	4.1	2895.5	6.9	444.8	300.5	146.1
1505	4.0		7.6	520.1	313.1	140.2
1510	3.9		8.1	551.5	317.8	151.9
1515	4.1	2746.3	8.9	668.4	330.7	146.1
1520	4.7	2910.4	8.2	706.8	289.9	128.5
1525	5.0	2880.6	8.0	703.1	297.0	128.5
1530	4.7	2552.2	7.5	586.5	281.3	122.7
1535	4.7	2417.9	7.0	546.5	265.2	116.8
1540	4.5	2358.2	6.1	491.6	260.1	116.8
1545	4.2	2328.4	6.4	425.4	257.7	116.8
1550	3.9	2268.7	6.4	470.4	270.7	116.8
1555	3.6	2283.6	6.3	437.9	257.7	116.8
1600	7.3	2243.5	5.3	413.2	93.5	107.6
1605	7.0	2291.7	5.6	477.9	90.7	116.6
1610	3.5	2238.8	6.4	495.9	249.1	105.2
1615	3.7	2417.9	6.3	421.2	261.3	111.0
1620	3.7	2388.1	7.0	448.6	275.8	111.0
1625	3.5	2537.3	6.9	451.8	255.4	111.0
1630	3.5	2403.0	7.4	466.2	273.4	122.7
1635	3.6	2552.2	7.3	484.7	270.7	122.7
1640	3.7	2447.0	7.4	503.5	270.3	122.7
1645	3.8	2283.6	7.5	499.7	276.6	122.7
1650	4.0	2268.7	7.2	552.9	265.6	122.7
1655	4.0	2238.8	7.2	582.6	272.3	116.8
1700	4.1	2253.7	7.2	511.7	272.3	105.2
1705	4.0	2358.2	6.8	520.8	261.7	111.0
1710	3.9	2209.0	7.0	502.7	265.6	105.2
1715	3.9	2194.0	6.5	470.5	277.0	105.2
1720	3.8	2149.3	7.2	485.6	249.9	111.0
1725	3.7	2417.9	6.8	476.6	258.9	99.3
1730	3.8	2746.3	6.5	444.8	252.3	93.5
1735	3.6		6.8	476.1	264.8	93.5
1740	3.5	2761.2	7.7	492.5	264.8	87.6
1745	3.7		6.9	459.9	285.6	93.5
1750	3.6		7.5	539.2	262.5	134.4
1755	3.4		7.3	594.7	276.6	146.1
1800	3.6		7.4	497.1	307.6	
1805	4.1		7.2	523.6	292.3	
1810	3.6		7.5	522.0	291.1	140.2
1815	3.9		7.4	516.9	300.1	163.6
1820	3.8	2507.5	8.5	535.4	296.2	163.6
1825	4.0	2380.1	8.7	530.1	293.4	169.4
1830	3.6		8.1	579.2	300.9	169.4
1835	3.7		7.5	569.3	315.0	111.0
1840	8.9	2409.6	8.1	597.6	694.4	106.4
1845	8.9	2402.0	8.2	625.5	626.1	101.6
1850	8.9	2445.4	8.3	632.8	491.9	119.2
1855	10.3	2909.1	7.2	511.5	439.5	693.5
1900	10.3	3079.0	7.3	520.7	420.6	364.6
1910	9.9	3177.7	7.0	590.6	376.0	463.6
1915	10.3	3224.0	7.5	546.5	360.3	525.9
1920	10.0	3000.9	7.4	547.2	347.7	613.6
1925	11.3	2917.6	7.3	540.5	304.0	656.4
1930	11.2	3011.9	7.5	559.9	304.4	618.2
1935	11.7	3003.5	7.4	544.0	295.4	565.9
1940	11.6	2905.5	7.6	501.2	203.1	563.3
NO. PTS.	84	72	84	84	84	81
MEAN	5.2	2649.3	6.8	493.3	239.3	176.6
STD. DEV.	2.2	279.8	0.9	78.6	116.9	141.4

APPENDIX D

NBS COAL FLY ASH DATA

TABLE D-1. NBS COAL FLY ASH SAMPLE ICAP ANALYSIS/NOT ASHED

08/23/85. E.V. Robb PAGE 1 OF 2

FOR SAMPLE NBS COAL FLY ASH STANDARD. 1633A

analyst sample i.d.: p-14/NBS Coal Fly Ash/not.ashed

****

GRAMS OF SAMPLE ANALYZED = 0.49250

	TOTAL MICROGRAMS FOUND (ug) ***********	NBS MICROGRAMS (ug) **********	WEIGHT PERCENT FOUND (%) *******	NBS WEIGHT PERCENT (%) *************
AS:	63.90	71.41 +/- 7	---	---
CD:	0.8650	0.493 +/- 0.07	---	---
CA:	---	---	0.8213	1.11 +/- 0.01
CR:	75.00	96.53 +/- 3.0	---	---
CU:	64.15	58.12 +/- 1.5	---	---
FE:	---	---	4.583	9.40 +/- 0.10
PB:	18.30	35.66 +/- 0.19	---	---
MG:	---	---	0.3530	0.455 +/- 0.01
NI:	1.500	62.55 +/- 1.9	---	---
SE:	< 4	5.07 +/- 0.3	---	---
NA:	---	---	0.6340	0.17 +/- 0.01
ZN:	113.0	108.4 +/- 4.9	---	---

TABLE D-1. NBS COAL FLY ASH SAMPLE ICAP ANALYSIS/NOT ASHED (Continued)

NBS COAL FLY ASH STANDARD 1633A CONTINUED: PAGE 2 OF 2

E.V.R..08/23/85

analvst sample i.d.: p-14/NBS Coal Fly Ash/not.ashed

****

THE FOLLOWING METALS ARE NOT CERTIFIED, BUT ARE GIVEN BY NBS FOR INFORMATION ONLY.

	TOTAL MICROGRAMS FOUND (uo)	NBS MICROGRAMS NOT CERTIFIED (ug)	WEIGHT PERCENT FOUND (%)	NBS WEIGHT PERCENT NOT CERTIFIED (%)
	***********	**************	*******	**************
AL:	---	---	7.354	14.0
SB:	15.95	3.45	---	---
BA:	---	---	0.05665	0.15
CO:	41.80	22.66	---	---
MN:	< 0.2	93.58	---	---
TI:	---	---	0.7284	0.8
V:	220.3	147.8	---	---

TABLE D-2. NBS COAL FLY ASH SAMPLE ICAP ANALYSIS/ASHED AT 110°C

```
08/23/85. E.V. Robb                                   PAGE 1 OF 2

FOR SAMPLE NBS COAL FLY ASH STANDARD, 1633A

analyst sample i.d.: p-18/NBS Coal Fly Ash/ashed.at.110'C

*******************************************

GRAMS OF SAMPLE ANALYZED = 0.92092


         TOTAL          NBS              WEIGHT
         MICROGRAMS     MICROGRAMS       PERCENT     NBS
         FOUND                           FOUND       WEIGHT
          (ug)                           (%)         PERCENT
                         (ug)                         (%)
         **********     **********       *******   *************

AS:      144.9          133.5 +/- 13.8     ---          ---

CD:      2.235          0.9209 +/- 0.14    ---          ---

CA:        ---            ---            0.8130    1.11 +/- 0.01

CR:      207.2          180.5 +/- 5.53     ---          ---

CU:      92.05          108.7 +/- 2.8      ---          ---

FE:        ---            ---            7.472     9.40 +/- 0.10

PB:      48.53          66.67 +/- 0.37     ---          ---

MG:        ---            ---            0.3526    0.455 +/- 0.01

NI:      < 0.1          116.9 +/- 3.7      ---          ---

SE:      < 4            9.49  +/- 0.55     ---          ---

NA:        ---            ---            0.1089    0.17 +/- 0.01

ZN:      224.1          202.6 +/- 9.21     ---          ---
```

TABLE D-2. NBS COAL FLY ASH SAMPLE ICAP ANALYSIS/ASHED AT 110^{o}C (Continued)

NBS COAL FLY ASH STANDARD 1633A CONTINUED: PAGE 2 OF 2

E.V.R..08/23/85

analyst sample i.d.: p-18/NBS Coal Fly Ash/ashed.at.110'C

****

THE FOLLOWING METALS ARE NOT CERTIFIED, BUT ARE GIVEN BY NBS FOR INFORMATION ONLY.

	TOTAL MICROGRAMS FOUND (ug) ***********	NBS MICROGRAMS NOT CERTIFIED (ug) *************	WEIGHT PERCENT FOUND (%) *******	NBS WEIGHT PERCENT NOT CERTIFIED (%) *************
AL:	---	---	11.94	14.0
SB:	25.79	6.45	---	---
BA:	---	---	0.004865	0.15
CO:	82.15	42.36	---	---
MN:	< 0.2	175.0	---	---
TI:	---	---	0.7378	0.8
V:	253.7	276.3	---	---

TABLE D-3. NBS COAL FLY ASH SAMPLE ICAP ANALYSIS/ASHED AT 600°C

08/23/85. E.V. Robb

PAGE 1 OF 2

FOR SAMPLE NBS COAL FLY ASH STANDARD. 1633A

analyst sample i.d.: p-19/NBS Coal Fly Ash/ashed.at.600'C

****

GRAMS OF SAMPLE ANALYZED = 0.60749

	TOTAL MICROGRAMS FOUND (ug)	NBS MICROGRAMS (ug)	WEIGHT PERCENT FOUND (%)	NBS WEIGHT PERCENT (%)
AS:	120.2	88.1 +/- 9.1	---	---
CD:	1.840	0.607 +/- 0.09	---	---
CA:	---	---	0.3997	1.11 +/- 0.01
CR:	89.50	119.07 +/- 3.6	---	---
CU:	82.40	71.68 +/- 1.8	---	---
FE:	---	---	8.173	9.40 +/- 0.10
PB:	41.45	43.98 +/- 0.24	---	---
MG:	---	---	0.1626	0.455 +/- 0.01
NI:	< 0.1	77.15 +/- 2.4	---	---
SE:	< 4	6.26 +/- 0.36	---	---
NA:	---	---	0.3038	0.17 +/- 0.01
ZN:	145.3	133.6 +/- 6.07	---	---

TABLE D-3. NBS COAL FLY ASH SAMPLE ICAP ANALYSIS/ASHED AT 600°C (Continued)

NBS COAL FLY ASH STANDARD 1633A CONTINUED: PAGE 2 OF 2

E.V.R..08/23/85

analyst sample i.d.: p-19/NBS Coal Fly Ash/ashed.at.600'C

****

THE FOLLOWING METALS ARE NOT CERTIFIED, BUT ARE GIVEN BY NBS FOR INFORMATION ONLY.

	TOTAL MICROGRAMS FOUND (ug)	NBS MICROGRAMS NOT CERTIFIED (ug)	WEIGHT PERCENT FOUND (%)	NBS WEIGHT PERCENT NOT CERTIFIED (%)
	***********	**************	*******	**************
AL:	---	---	11.29	14.0
SB:	19.50	4.25	---	---
BA:	---	---	0.01176	0.15
CO:	64.85	27.94	---	---
MN:	< 0.2	115	---	---
TI:	---	---	0.8737	0.8
V:	214.9	182.3	---	---

APPENDIX E
FILTER BLANK ICAP ANALYSIS

Appendix E contains Filter Blank ICAP Analysis and an example filter blank correction.

TABLE E-1. FILTER BLANK ICAP ANALYSIS/FIRST BOMB

```
]
08/21/85. E.V. ROBB
FOR SAMPLE 6276/HR-C-BL/HR-13/FIELD.BLANK/FIRST.BOMB:
****************************

THE GRAMS OF SAMPLE ANALYZED = 2.1E-03.

THE SAMPLE WAS ANALYZED ON 07/05/85.

             ORIGINAL PPMS          TOTAL MICROGRAMS          WEIGHT PERCENT
               (UG/ML)                    (UG)                (UG/G) X 100%
             **************         *****************         ***************

AL:           76.784                 3839.2                  182819048
SB:          <.07 (0.0)             <3.5 (0.0)              <166666.667
AS:           .29                   14.5                      690476.191
BA:455        .662                   33.1                      1576190.48
CD:           .094                  4.7                       223809.524
CA:317        930.5                   46525                        2.21547619E+09
CR:           2.78                  139                       6619047.62
CO:           .426                  21.3                       1014285.71
CU:           .352                  17.6                       838095.238
AU:           .058                  2.9                       138095.238
FE:ave.       31.825                  1591.25                       75773809.5
PB:ave.       1.05                  52.5                       2500000
MG:279.08     137                  6850                       326190476
MN:           1.779                   88.95                        4235714.29
NI:           4.15                  207.5                      9880952.38
P:           <.03 (0.0)            <1.5 (0.0)                <71428.5715
SE:           .327                  16.35                      778571.429
AG:          <4E-03 (0.0)           <.2 (0.0)                <9523.80953
NA:           57                   2850                      135714286
S:ave.        12.39                   619.5                       29500000
SN:           .71                  35.5                      1690476.19
TI:           12.85                   642.5                       30595238.1
V:            .256                  12.8                       609523.81
ZN:           3.67                  183.5                       8738095.24
```

TABLE E-2. FILTER BLANK ICAP ANALYSIS/REBOMB

]
08/21/85. E.V. ROBB
FOR SAMPLE 6276/F/HR-C-BL-F/HR-13/FIELD.BLANK/REBOMB.OF.RESIDUE.FROM.FIRST.BOMB:
****

THE GRAMS OF SAMPLE ANALYZED = 2.1E-03.

THE SAMPLE WAS ANALYZED ON 07/05/85.

	ORIGINAL PPMS (UG/ML)	TOTAL MICROGRAMS (UG)	WEIGHT PERCENT (UG/G) X 100%
AL:	128.09	6404.5	304976191
SB:	< .07 (0.0)	<3.5 (0.0)	<166666.667
AS:	1.03	51.5	2452380.95
BA: 455	.097	4.85	230952.381
CD:	.027	1.35	64285.7143
CA: 317	449	22450	1.06904762E+09
CR:	.875	43.75	2083333.33
CO:	.107	5.35	254761.905
CU:	.133	6.65	316666.667
AU:	<.04 (0.006)	<2 (0.300)	<95238.0953
FE: ave.	13.175	658.75	31369047.6
PB: ave.	.78	39	1857142.86
MG: 279.08	63.5	3175	151190476
MN:	.039	1.95	92857.1429
NI:	.18	9	428571.429
P:	<.03 (0.0)	<1.5 (0.0)	<71428.5715
SE:	<.08 (0.0)	<4 (0.0)	<190476.19
AG:	<4E-03 (0.0)	<.2 (0.0	<9523.80953
NA:	133.05	6652.5	316785714
S: ave.	2.028	101.4	4828571.43
SN:	.234	11.7	557142.857
TI:	.536	26.8	1276190.48
V:	.038	1.9	90476.1905
ZN:	.204	10.2	485714.286

TABLE E-3. EXAMPLE FILTER BLANK CORRECTION FOR FIRST BOMB
(Run 04-Baghouse Inlet)

```
]
08/28/85. E.V. ROBB
FOR SAMPLE 6275/F/FIRST.BOMB/HR-A4-F/HR-69:
****************************

THE SAMPLE WAS ANALYZED ON 07/05/85.

THE GRAMS OF SAMPLE ANALYZED = .149.

                 ORIGINAL UG          BLANK CORRECTED          WEIGHT PERCENT
                    (UG)                   (UG)                    (UG/G)
                 ***********          ***************          **************

AL:              16495                12655.8                  84938.255
SB:              72.65                72.65                  487.583893
AS (0-50):       146.5                132                  885.906041
BA:455           53.85               20.75                 139.261745
CD:              3440                3435.3                23055.7047
CA:317           17325               + <0,35            + <2,349
CR:              57.5               + < 2               + <13,42
CO:              15.75               + <5                + <33,56
CU:              1127.5               1109.9                 7448.99329
AU:           <2                  + <2               + <13.42
FE:ave.          1142.5               + <0,25            + <1,678
PB:ave.          2254                2201.5                14775.1678
MG:279.08        4525                + <0,15            + <1,007
MN:              29.75               + <0,2             + <1,342
NI:              179.5               + <0,1             + <0,6711
P:               1095.5               1095.5                7352.349
SE:           <4                  + <4               + <26.85
AG:              32.85               32.85                 220.469799
NA:              2962.5               112.5                 755.033557
S:ave.           15861.5               15242                  102295.302
SN:              577.15               541.65                 3635.2349
TI:              517.75               + <0,45             + <3,020
V:               624                611.2                4102.01343
ZN:              1432.5               1249                 8382.55034
```

TABLE E-4. EXAMPLE FILTER BLANK CORRECTION FOR REBOMB
(Run 04-Baghouse Inlet)

08/29/85, ESTHER V. ROBB
FOR SAMPLE 6275/F/HR-A4-F/HR-89/REBOMB:
****

THE SAMPLE WAS ANALYZED ON 07/05/85.

THE GRAMS OF SAMPLE ANALYZED = 0.149.

	ORIGINAL UG (UG)	BLANK CORRECTED UG (UG)	WEIGHT % (UG/G)
AL:	18795	12390.5	83157.7181
SB:	7.65	7.65	51.3422818
AS:	19	~~0~~ <4	~~0~~ <26.85
BA: 455	39.7	34.85	233.892617
CD:	556.25	554.9	3724.16107
CA: 317	26500	4050	27181.208
CR:	54.45	10.7	71.8120805
CO:	7.2	~~1.85~~ <5	~~12.4161073~~ <33.56
CU:	157.05	150.4	1009.39597
AU:	<2	~~1.7~~ <2	~~11.4093959~~ <13.42
FE: ave.	828.75	828.75	5562.08053
PB: ave.	282.75	243.75	1635.90604
MG: 279.08	345	~~0~~ <0.15	~~0~~ <1.007
MN:	13.45	11.5	77.181208
NI:	55.5	46.5	312.080536
P:	<1.5	<1.5	<10.067114
SE:	<4	<4	<26.8456375
AG:	15.6	15.6	104.697986
NA:	10365	3712.5	24916.1073
S: ave.	1783.6	1682.2	11289.9328
SN:	231.5	219.8	1475.16778
TI:	116.05	89.25	598.993288
V:	77.4	75.5	506.711409
ZN:	253.05	242.85	1629.86577